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CORPORATION

AKRON 15, OHIO

112761

M-1-L RE-ENTRY VEHICLE

(WIND TUNNEL MODEL, FULL-SCALE)

DESIGN, FABRICATION, AND TESTING

Final Report, 10 aug. 1962 - 15 nov. 1963

(NASA CR - - - GER-11141)

30 January 1964

(NASA Contract NAS 2-1037)

OTS: $10.10 ph

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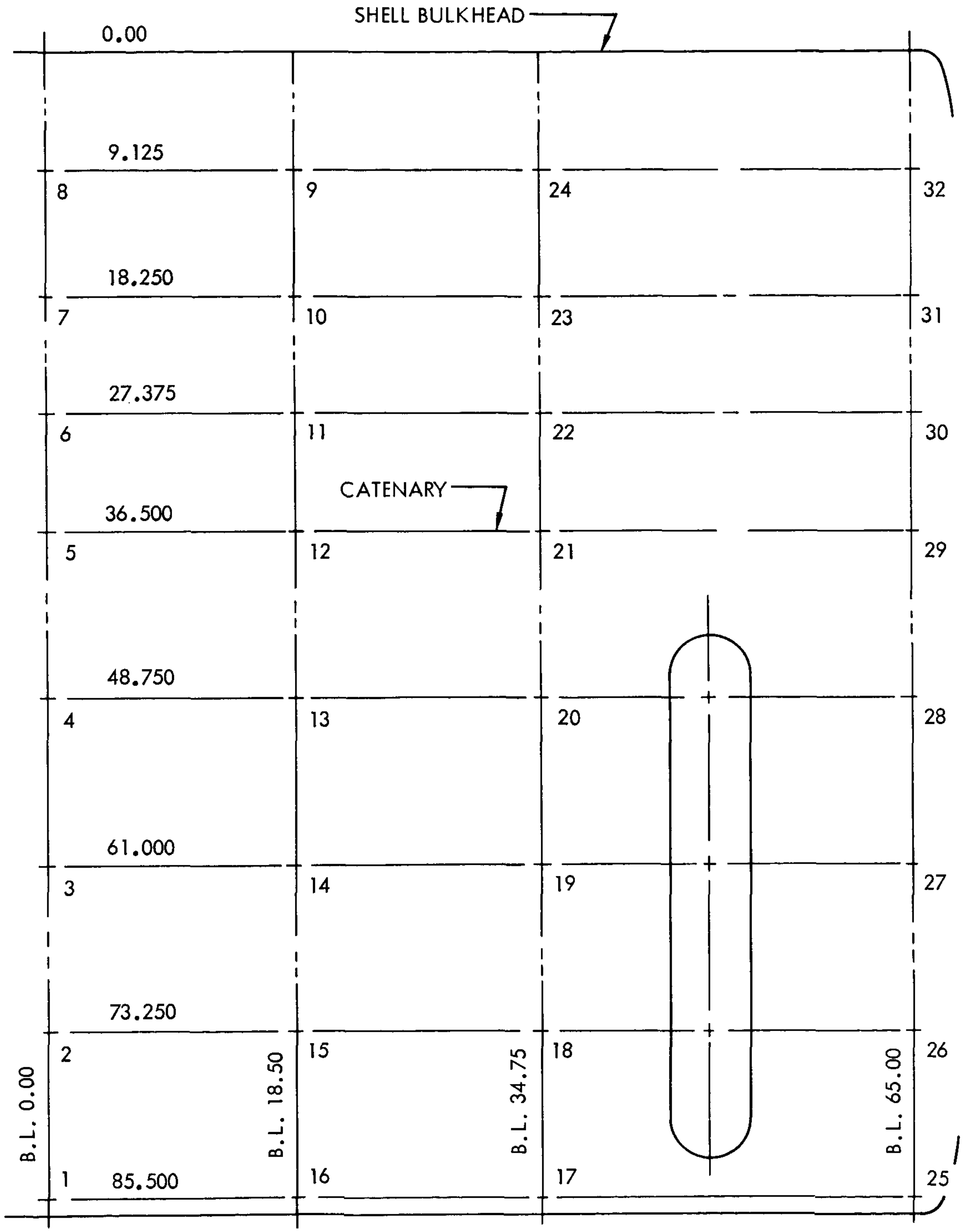


Figure 1. Gage Locations

INTRODUCTION

This final report summarizes the work performed by Goodyear Aerospace Corporation in the design, fabrication, and testing (exclusive of Wind Tunnel) of the M-1-L full-scale wind tunnel model. This model concept of the M-1 re-entry body with a deployable-inflatable afterbody was sponsored by the National Aeronautics and Space Administration under terms of Contract NAS 2-1037 and conforms with NASA Specification NAS 2-1037, dated 13 August 1962, which for clarity is quoted herein as Appendix A.

The design and fabrication effort commenced on 13 August 1962, and the model was completed and ready for static test on 27 June 1963. Upon commencement of the static test, an AIRMAT* failure occurred which necessitated a study and analysis of the failure. Details of the failure and remedial action taken are included in Section II. Subsequent add-on funding was obtained for a complete rebuild of the model. The new M-1-L was fabricated and successfully passed its proof, static, and deployment tests and was shipped via USAC truck from the contractor's plant (Akron, Ohio) on 21 January 1964.

Progress reports, References a1 through a13, cover the principal areas of endeavor for the period 10 August 1962 through 15 November 1963. The significant accomplishments in major areas of effort are discussed in this report, which consists of the following sections:

- I. Material Preparation
- II. Material Testing
- III. Engineering Analysis
- IV. Detail Design

*TM, Goodyear Aerospace Corporation, Akron, Ohio

V. Model Fabrication

VI. Model Testing

VII. Deployment System Description and Operating Instructions

VIII. Operation Log

The NAS 2-1037 Specification for the M-1-L vehicle is included in this report as Appendix A, and a structural analysis of the wind tunnel model is presented in Appendix B.

SECTION I. MATERIAL PREPARATION

Initial effort consisted of weaving approximately 124 feet of six-inch AIRMAT on the Goodyear Aerospace loom facility and was performed in an over-all seven-week period extending from 13 August to 28 September 1962. This quantity provided 100 percent excess material and was woven to provide an adequate supply should any unforseen problems arise requiring some scrappage.

This AIRMAT conforms to the following Goodyear Aerospace specification:

Warp, Fill, and Drop Yarns-220. Denier, Type 51,
Dacron HT (High Tenacity)

7 TPI ~ 50 filaments/yarn

112. Warp, yarns/in.

40. Fill, yarns/in.

47.2 drop yarns/in.^{2}

Warp Direction ~ 8 drop yarns/in.

Fill Direction ~ 5.9 drop yarns/in.

Subsequent to the weaving operation, two plies of cover fabric were applied using the Goodyear Aerospace autoclave as the temperature and pressure device. This single-ply Dacron fabric is identified as GT&R code ZX-392, with specified strengths of 262 lb/in. and 247 lbs/in. in the warp and fill directions.

SECTION II. MATERIAL TESTING

1. General

To predict the burst strength of the selected AIRMAT, tensile tests were conducted on an Instron testing machine on 50 samples of the AIRMAT drop threads. These tests yielded the following average values:

Straight break = 3.16 pounds

Loop break = 2.60 pounds

Then with the drop thread count of 47.2 drop threads/in.^{2} and assuming 80 percent effective drop threads, the predicted strength would be 47.2 (2.60) (0.80) = 100 psi.

2. Test Results

To verify the foregoing predicted burst strength, a series of test specimens was fabricated and tested. The tests yielded the following results:

(1) The reference b3 pillow specimen failed at an air pressure of 48 psi. The failure was explosive in nature; however, a review of the failed specimen indicated that the failure was precipitated by inadequate strength in the area of the input valve. These areas in the M-1-L were then suitably reinforced.

(2) As a result of the Reference b3 test, another pillow-type specimen (Reference b8) was fabricated with the improvement in the valve input area. This specimen failed at 90.8 psi and was reported in Reference a4. Since this test did not meet the predicted strength of 100 psf, it was agreed to fabricate a test specimen of the fin intersection joint (Reference b27).

(3) Also in this general period, tests were conducted on the Reference b4 through b7 specimens and verified the specified 500 lb/in. allowable loading of the woven "X" seam material.

(4) The Reference b27 fin intersection test specimen was tested as follows:

(a) A proof pressure of 37.5 psi was applied and held for 15 minutes without failure, although a minor leak in the woven "X" required repair prior to the test conclusion.

(b) The specimen was subjected to a torque load of 19,200 lb/in. when inflated to 25 psi without damage or excessive deformation.

(c) By use of a dry nitrogen bottle source, the specimen was inflated from 0 to failure at 79 psi in 3.2 seconds. Prior to this test and during the process of fabrication, this specimen had been subjected to the proof pressure of 37.5 psi on several occasions. On conclusion of each of these proof pressure applications, a visual inspection revealed certain minor discrepancies, such as a small leakage in the vicinity of the woven "X" seam material. The specimen was accordingly taken apart and rebuilt to correct the condition. As a result of these several reworks, it is quite probable that the specimen suffered some internal, and not visible, damage that resulted in the failure of the specimen at approximately 80 percent of the theoretical.

3. Original Static Test

The static test was started on 21 June 1963. When 25 psi in the AIRMAT surfaces, 0.20 psi in the fabric shell, and approximately 100 gallons of the planned 420 gallons of water for the airload simulation had been applied, a delamination between the top forward and top aft AIRMAT juncture occurred. The test was therefore called off, and a suitable repair was incorporated.

Upon completion of the repair, it was planned to accomplish the following:

(1) Subject the M-1-L inflatable afterbody to the proof pressure of 37.5 psi and hold for 15 minutes.

(2) Reduce the pressure to 25 psi and then continue with the static test.

When in the process of applying the proof pressure, a catastrophic failure occurred when 25 psi had been applied. This model had previously been subjected to 25 psi many times during its fabrication, and it is estimated to have been under this pressure for approximately 50 hours during the assembly. In addition, the proof pressure was applied once, just prior to attachment of the afterbody to the forebody.

The resulting review and analysis of the failure, as shown by the photographic references e28 and e29 of Reference a10, can be stated by the following hypothesis of the failure sequence: The initial failure occurred in the internal support as an AIRMAT drop thread slippage at the edge immediately adjacent to the internal support web. This initial slippage caused overloading of the adjacent threads, and slippage progressed inward on the AIRMAT until the increasing rate of application of load and the anchoring of the drop threads were sufficient to cause failure to manifest itself as a tension failure of the drop thread.

Subsequent to the test review and analysis, a series of 28 test specimens was fabricated with improved methods of assuring adequate anchorage of the drop threads to the face material. The results show that, with a liberal application of cement to the juncture of drop threads with the face material, no drop thread slippage should occur. To further substantiate this approach, six 18 x 24 inch pillow specimens were fabricated using salvaged AIRMAT material from the originally failed M-1-L afterbody. These specimens were subjected to a hydrostatic pressure test and failed in approximately 15 - 18 seconds at the following values:

a. 60
b. 65 } 65 average
c. 70
d. 75
e. 76 } 76.7 average
f. 79

Both the reduced rate of loading and the previous history of loading of the AIRMAT material from which these specimens were fabricated tend to decrease the ultimate strength. It has been past practice to define a quick break test as one where the ultimate strength is reached in less than 6 seconds. Therefore, the assumption is that, if the specimens were tested at a higher loading rate and were fabricated from virgin material, a pressure of 80+ psi would be achieved. At this time, it was determined that the normal operating pressure could be reduced to 20 psi in lieu of 25 psi and still limit the deflection of the AIRMAT surfaces when operating at a tunnel dynamic pressure of 100 psf. Specimens (a) through (c) had no special treatment to secure the threads and failed by drop thread slippage. Specimens (d) through (f) had a liberal application of cement to the juncture of the threads with the face material.

At this time, it was decided to fabricate four additional pressure specimens in an effort to prove the considered 80 psi allowable. The material for these specimens was taken from the aft panel of the original M-1-L. These specimens, two pillows and two fin intersections, reported in Reference a13, were subjected to cycling as well as ultimate pressure testing.

In analyzing the results of these tests, it was notable that the contractor had not been able to achieve a failure of the joint type intersection as intended, but had failed only small patch areas or places where the specimens were capped off. It is considered that these premature failures were the result of trying to use only available and previously fabricated AIRMAT components or portions thereof that did not lend themselves to fabrication of acceptable test specimens due to excessive buildup of layers of fabric, cement, and resulting local stiffness. It is considered that the test objective of showing the joint construction to be adequate for an 80 to 90+ psi ultimate pressure would have been achieved, if it had been possible to use new AIRMAT. It is considered that the new M-1-L, i.e., using new AIRMAT and the new joint/drop thread anchorage technique, will prove far superior to any of the specimens to date.

SECTION III. ENGINEERING ANALYSIS

In order that the structural integrity of the model could be assured, a design analysis (Appendix B) was made during the course of design and fabrication.

Early in the program, the contractor established that the inflation system would provide complete inflation of the AIRMAT components to 10 psi in 2 seconds and reach the maximum design operating pressure of 25 psi in a total inflation time of 6 seconds.

Subsequently, and as a result of an AIRMAT failure during the first attempted static test, the maximum operating pressure was reduced to 20 psi and the inflation system was modified accordingly, with the result that the system now will inflate to 10 psi in 2 seconds or less and to 20 psi in 6 seconds or less.

Section VII contains a description of the deployment system and operating instructions.

SECTION IV. DETAIL DESIGN

The detail design of the M-1-L as described herein is depicted by the drawings in References b1 through b28 and References c and d.

SECTION V. MODEL FABRICATION

The M-1-L model fabrication was documented by Reference e1 through e4 and e8 through e27 photographs, which were included in References a6, a7, a8, a9, and a10.

SECTION VI. MODEL TESTING

1. Proof Pressure

The AIRMAT portion of the present M-1-L was first pressure tested on December 16, 1963. The proof pressure test was started but was stopped at 13 psi when leaks were detected around the fin intersection of the top section.

The faulty areas were easily repaired, and the proof pressure test was conducted on December 26, 1963. The AIRMAT portion was pressurized to 24 psi and held at this pressure for 30 minutes. The pressure in the AIRMAT was then reduced to 20 psi and held for one hour. There were some minor leaks detected, but these were not significant and were easily repaired. The proof pressure test was considered successful.

2. Static Load Test

The M-1-L re-entry body was suspended inverted from the universal test fixture with the solid bulkhead of the forebody at an angle of 65^{O}F with respect to the horizontal (Reference a5, except p = 20 in lieu of 25 psi). Vertical deflection scales were attached to the AIRMAT surface at four spanwise stations (see Figure 1). Eight scales were located along the AIRMAT in a chordwise direction at each of the spanwise locations to determine the contour of the AIRMAT surface when it is statically loaded, simulating a dynamic pressure of q = 100 psf and an angle of attack at 28. 5 degrees. The deflection scales were read with the aid of three levels. A set of reference readings of these scales was made with the AIRMAT pressurized to 2 psi.

The AIRMAT was pressurized to 10 psi, and the shell was pressurized to 0. 375 psi. The theoretical position of the catenary was located by deflection scale readings and drawings. The catenary was then adjusted to the theoretical position.

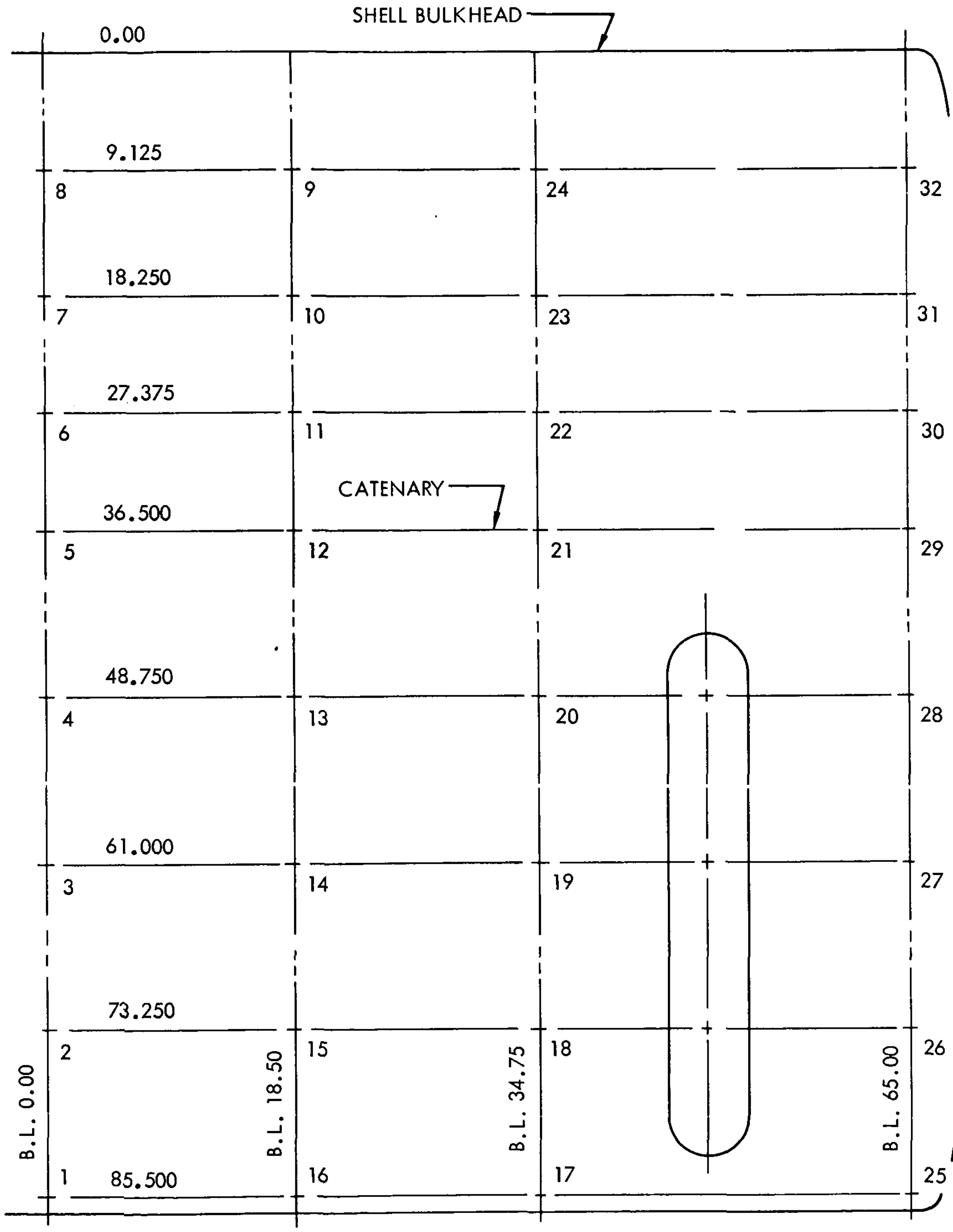


Figure 1. Gage Locations

The shell pressure was maintained at 0.375 psi, and the AIRMAT pressure was raised to 20 psi. Then a 50 percent load of water (1750 pounds) was added to the inner surface of the AIRMAT. The contour change caused by the water load was determined by plotting the changes indicated by the deflection scales.

The AIRMAT pressure was maintained at 20 psi, the shell pressure was increased to 0.50 psi, and the water load was increased to 3500 pounds (100 percent). The deflection scales were read again and recorded. The plots of the actual contour versus the theoretical contour at each of the four spanwise stations are shown in Figures 2 through 5.

The AIRMAT was at 20 psi for two hours during the test period.

In order that the NASA specified contour can be achieved, it will be necessary to take in the catenary by the following values for either a 50 or 100 psf dynamic pressure test:

	B. L.	Contour Adjustment	Catenary Adjustment Required
	0.00	1.70 in.	
Inboard	± 16.00		1.60 in.
	18.50	1.40 in.	
	34.75	1.40 in.	
Outboard	± 44.00		1.30 in.
	65.00	0.70 in.	

This adjustment was not made prior to delivery, because the length of cable and turnbuckle assemblies was such that all the adjusting length had been used. As a result of this, new cable/turnbuckle assemblies were made and installed with the tested setting prior to delivery. However, it was not possible to make the adjustment, because the M-1-L was being packaged and loaded on the truck for delivery at that time. It is suggested that Ames take in the turnbuckle lengths by the noted 1.60 and 1.30 inch to provide the specified contour.

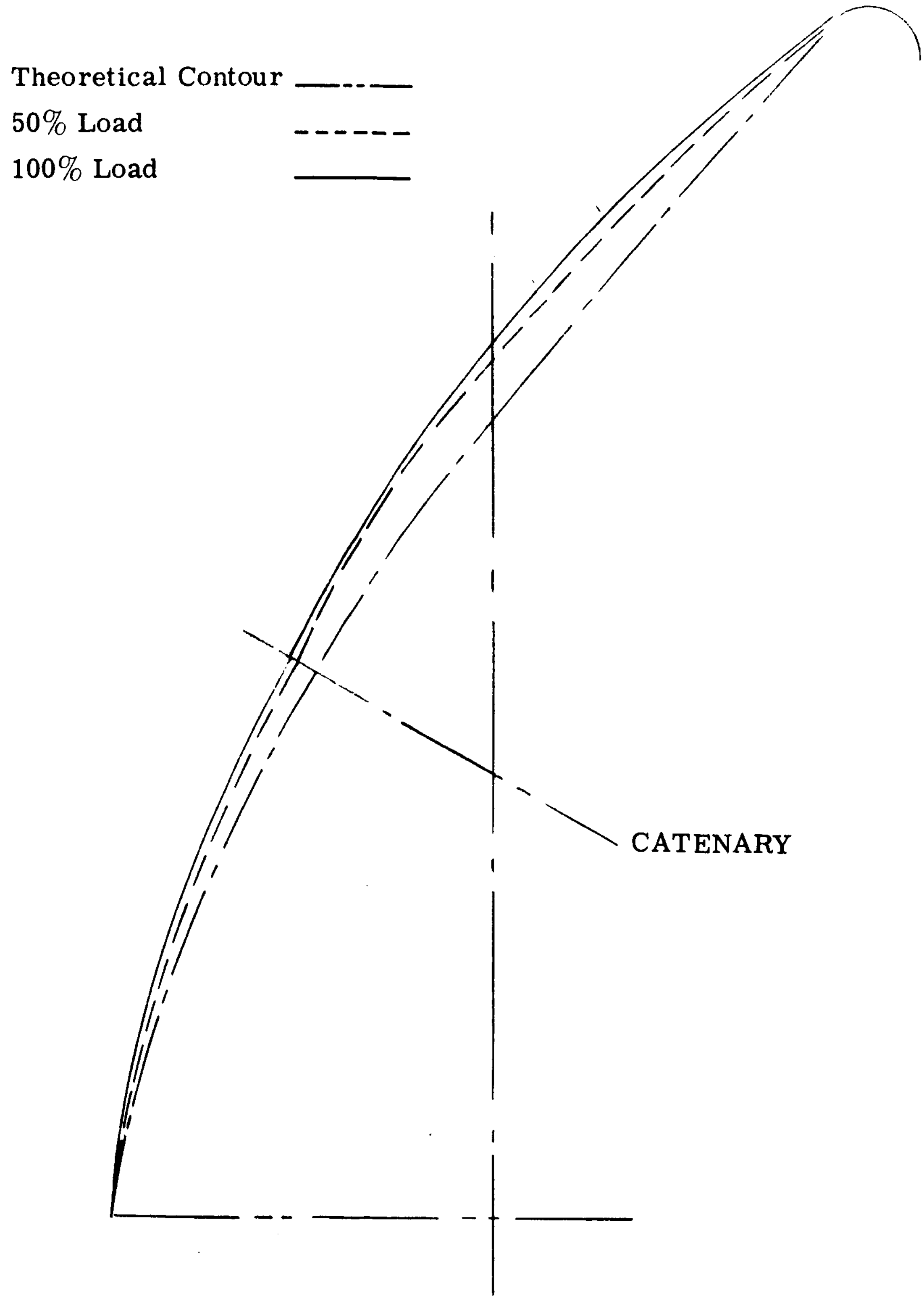


Figure 2. B. L. 0.00 Contour

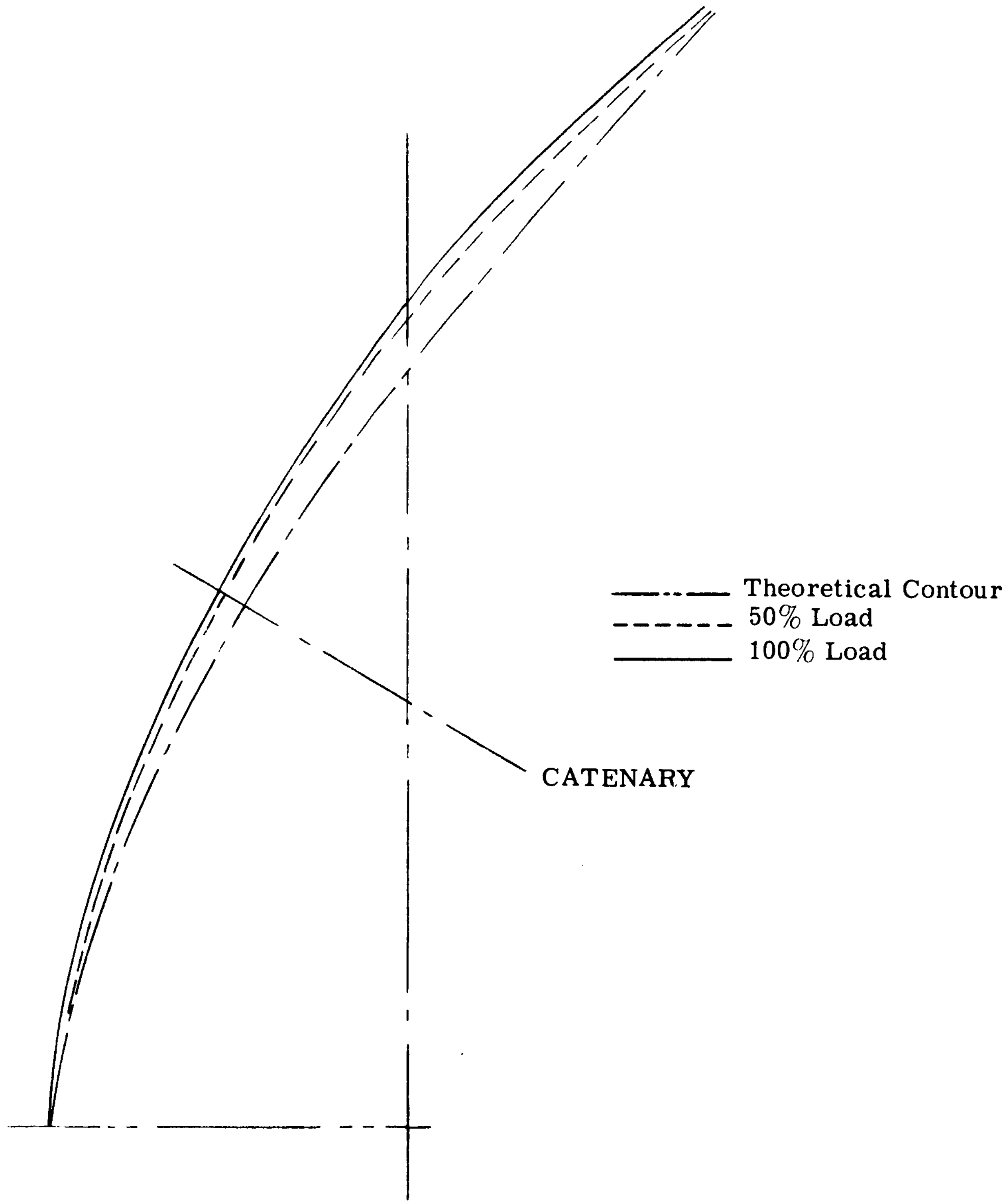


Figure 3. B. L. 18.50 Contour

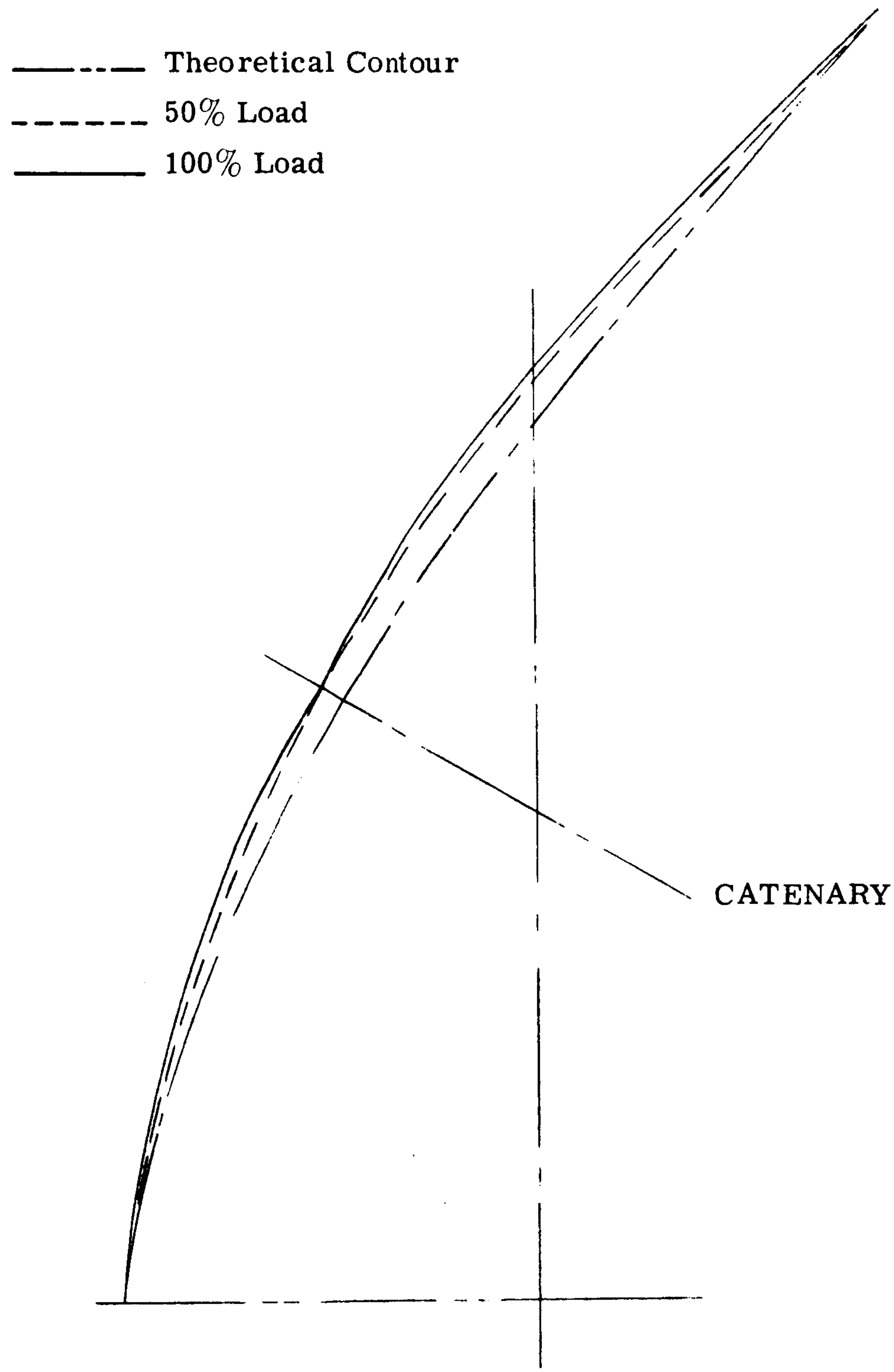


Figure 4. B. L. 34. 75 Contour

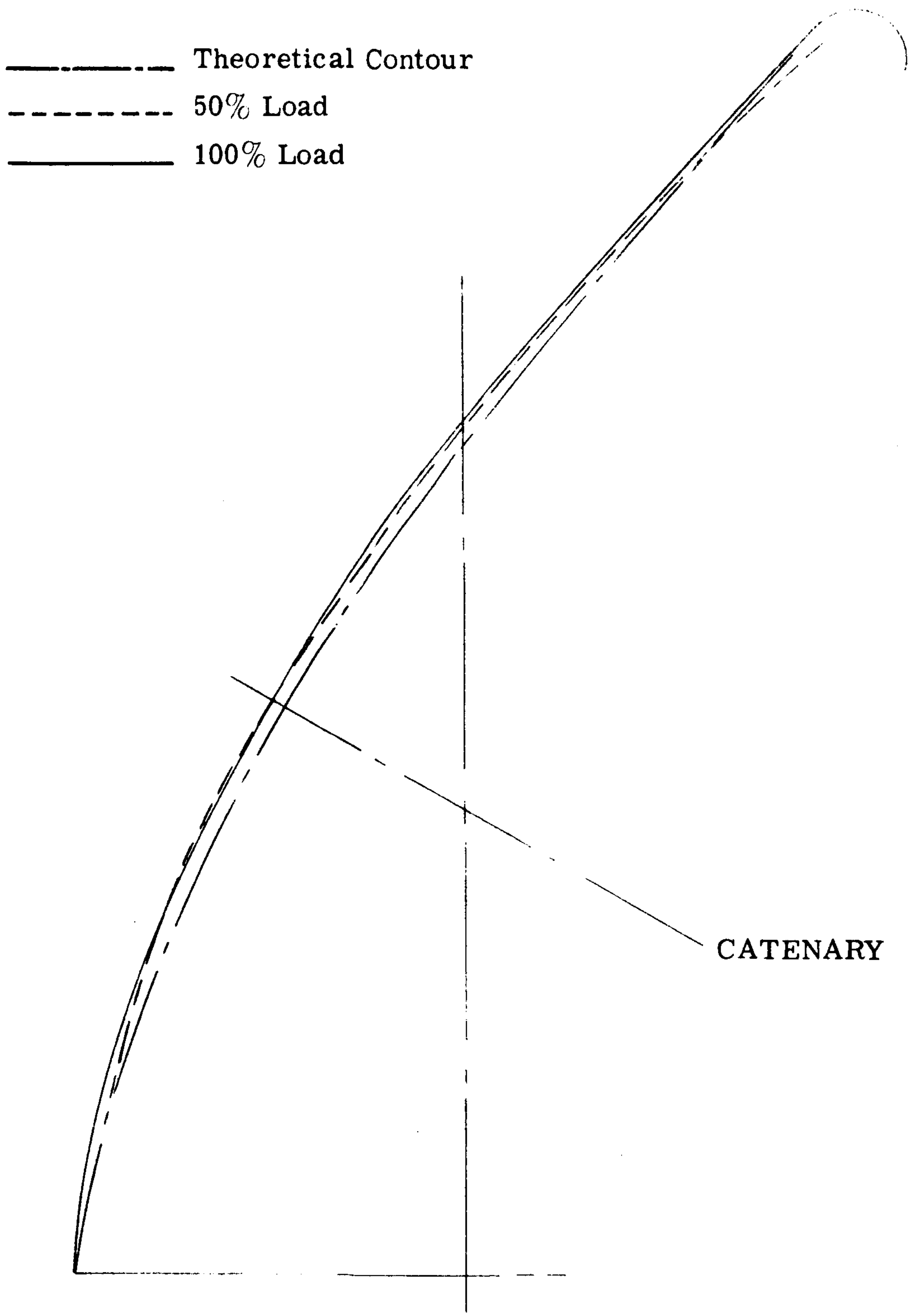


Figure 5. B. L. 65.00 Contour

3. System Inflation Tests

The bottle inflation system was checked out by using a pressure vessel into which the bottles could be expended. The volume of the pressure vessel (100 cu ft) was approximately the same volume as the estimated volume of the AIRMAT.

The inflation lines and the pressure sensing lines were disconnected from the AIRMAT and connected to the pressure vessel. Each of the four pressure bottles was charged to 500 psi. Each bottle was expended individually to check out the individual systems. Each system was found to operate satisfactorily. When all four bottles were expended into the pressure vessel, the pressure in the vessel was 9.75 psi. Each bottle was then charged to 700 psi, which was calculated to pressurize the pressure vessel to 15 psi. All valves were energized at one time, and the pressure gage in the pressure vessel indicated 15.38 psi. Each bottle was then pressurized to 1100 psi. This bottle pressure was calculated to yield a pressure of 23 psi in the pressure vessel. This pressure level was selected to determine that the regulator valves would not allow an over-pressure in the AIRMAT. These regulators were factory-adjusted to limit the pressure in the AIRMAT to 20 (±1.5) psi. All the bottles were exhausted simultaneously; a pressure level of 22 psi was indicated at the pressure vessel when the system stabilized. The pressure was allowed to drop to 19 psi in the pressure vessel, the inflation system was activated again, and the remaining pressure in the bottle system increased the pressure to 19.5 psi before all the remaining air supply was exhausted. This indicated that the regulator system did function. As a further check on the regulator system, each regulator was checked out by pressuring each bottle to 500 psi and controlling the sensing back-pressure to the regulator by means of regulated shop air. The regulators were found to function properly within the reported tolerance; they would allow flow from the bottle, when the pressure at the sensing port was approximately 20 psi and stop the flow from the bottles when the sensing pressure was 20.5 psi or greater.

The regulators were found to function within the specified limits when the bottle pressure was as low as 150 psi. It was found that when the bottle pressure was decreased to 50 psi, the sensing back-pressure had to be increased to 23 psi to stop the flow from the bottle.

4. Door Check

The purpose of the test was to check the operation of the large and small scoop doors that are used to maintain the shell pressure from the ram tunnel air. The large door should close when the shell pressure exceeds 0.10 psi. The small door should close only when the shell pressure is 0.20 psi.

The shell pressure was gradually increased to 0.10 psi; at this pressure level the large door closed. The shell pressure was increased further until the small door closed. The pressure at which the small door closed was 0.15 psi. This test was repeated with the same results. The low pressure level at which the small door closed is attributed to the tolerances on the components of the pressure sensing system incorporated in the design of these valve systems. The 0.15 psi pressure level is considered acceptable.

5. Squib Check

The six squib-fired cable cutters for release of the inflated afterbody packaging cover were installed in their respective positions on the forebody. Nylon cable was threaded through each cable cutter and secured to the guide studs on the outside of the forebody. To check the safety switch operation, which deenergizes the squib circuitry when the access door is removed, voltage was applied through the control box and the squibs did not fire, as intended. The access door was installed, voltage was applied through the control box, and the squibs fired, as intended.

6. Packaging and Deployment

The AIRMAT was evacuated, and the forward skirt of the cover was attached to the forebody by securing the draw cable to the guide posts. The cable was stretched taut to keep the cable in the groove provided on the forebody. The afterbody was packaged by folding the fins outboard and then folding each outboard tip of the top surface AIRMAT toward the center. A fold was thereby formed from each top corner of the forebody intersection down in front of the fin to the center of the AIRMAT panel. The inner supports were folded in and up along with the lower section of the back AIRMAT panel. The back panel of the cover was then laced on to the forward skirt. The cables securing the cover were cut, the cover was pulled away, and the AIRMAT and shell were inflated by means of factory air supply and a compressor. The inflatable portion unfolded and deployed without any apparent difficulties.

SECTION VII. VEHICLE DEPLOYMENT SYSTEM DESCRIPTION AND OPERATING INSTRUCTIONS

1. Introduction

The deployment and inflation system of the M-1-L vehicle afterbody is designed to deploy the afterbody by inflation and pressurization of the AIRMAT structure from a stored gas source, and to inflate and pressurize the afterbody shell or cavity by controlling the operation of air scoop doors, which pick up ram air as required to develop and maintain pressurization. The system includes all necessary components to control the operation and the instrumentation to indicate performance.

The vehicle afterbody AIRMAT section inflation system is designed to provide pressurization to 20 (±1.5) psig in approximately 6 seconds or less. Since the study of the aerodynamic characteristics of the vehicle afterbody is of prime importance, all wind tunnel testing should be conducted with reduced gas flow when using pressure from the gas storage cylinders, since cycles of rapid inflation and pressurization appreciably decrease the life expectancy of the fabric. Reduced gas flow is achieved by controlling the gas flow through a calibrated needle valve. The recommended gas flow for wind tunnel testing is 1/4 when using pressure from the gas storage cylinders. The ultimate capability of the vehicle afterbody inflation system, which includes afterbody cover separation, should be checked out, but only after all other wind tunnel testing has been completed.

2. System Description

The system consists of four essentially identical subsystems. Each is comprised of a 3000-psi maximum storage cylinder, a gas cylinder valve, a calibrated needle valve, a solenoid shut-off valve, and a pressure reducer valve with remote outlet sensing. The outlet and sensing ports of the pressure reducer valve are connected to the AIRMAT.

On one of these four subsystems, the ram air scoop door positioning system is teed into the line between the solenoid shut-off valve and the pressure reducer. In this air scoop door system are a pressure reducing valve, two four-way valves, and two double-acting pneumatic cylinders that open and close the ram air intake scoop doors. Two differential pressure switches sense the afterbody shell pressure as compared to tunnel ambient pressure and control the four-way valves to cause opening or closing of the ram air intake scoops as required to maintain the design shell pressure.

Pressure transducers are provided to indicate afterbody AIRMAT pressure and shell pressure. A rotary potentiometer is mounted on each ram air intake scoop door to indicate scoop door position.

3. Preparation for Inflation

The storage bottles with gas cylinder shut-off valves are removable from the vehicle as a unit for recharging. After reinstallation and connection into the system, the gas cylinder valve is opened, the needle valve is positioned to the desired flow, and the system is ready for operation. The needle valves have been calibrated and marked to permit 1/4, 1/2, 3/4, and full flow. For all aerodynamic testing, it is recommended that the needle valves be set for 1/4 flow for reasons explained in the introduction.

4. Inflation Sequence

When deployment is desired, power is applied to the normally closed solenoid valves to open the valves, allowing high pressure gas to flow to the pressure reducer valves. These valves remain open, and gas continues to flow until the AIRMAT pressure has reached the operating pressure of 20 (±1. 5) psi. At this point, the valve closes; the valve will reopen automatically only if AIRMAT pressure drops due to leakage or other loss.

The gas storage cylinders are sized so that after initial inflation and pressurization are complete there will remain in the bottles a sufficient quantity of gas to maintain pressure for at least several hours with expected leakage rates.

5. Scoop Operation

When the solenoid valve is opened in the system to which the air scoop operating system is fed, high pressure gas also flows to the pressure reducer valve in this system and reduces the pressure to 100 psi as long as upstream gas pressure measures greater than 175 psi. From here, the gas flows to the two four-way valves, which in turn direct the gas to the double-acting actuators to open or close the ram air scoop doors automatically on demand. The valves are internally arranged such that, with no electrical power applied, gas is directed to keep both scoop doors open. With electrical power applied and with afterbody shell pressure below the desired design pressure, the differential pressure switches will be closed and the valves will port gas to the actuators to open both scoop doors.

Two ram air intake scoop doors are used to maintain a close control of afterbody pressure. The large scoop door will provide a rapid pressure rise. Because of this and the time response of the system, this door must start to close at a pressure considerably below 0.2 psi to avoid excessive variations in shell pressure. Therefore, the pressure switch must be set at 0.1 psi. For the large scoop door to open, the pressure would need to drop below 0.1 psi. The small scoop door, which produces a much lower rate of pressure increase, is controlled by the other pressure switch set at approximately 0.2 psi. By using two such doors, pressure variations are held to an acceptable level.

6. Provisions for External Pressure Source

Facilities for using external air sources for inflation and pressurization of the AIRMAT are incorporated in the same subsystem containing the ram air intake scoop door system. Removable tube assemblies are made accessible, and an adapter tube assembly (normally mounted on a stowage receptacle on the forebody bulkhead) is provided. The 3/4-inch tube assembly, color coded yellow and tagged "Remove for AIRMAT External Pressure", located between the solenoid valve and the tee, is removed and replaced with the adapter tube assembly (tagged "AIRMAT External Pressure Connection Gauge Regulated Pressure Not To Exceed 20 PSI"). Included in the adapter tube assembly is a relief valve with a factory setting of 20 psi. The adapter tube assembly is attached to the tee. This arrangement permits controlled inflation and pressurization of the AIRMAT section only. The ram air intake scoops are inoperative if upstream pressure is less than 175 psi. For ram air intake scoop operation when using an external source pressure of 175 psi minimum, it is necessary to remove 1/2 OD tube assembly tagged "Remove for Door Actuator External Pressure, Install Cap on Reducer". The reducer (AN919-19) is capped, and an external source pressure with a minimum 175 psi is adapted to the nipple tagged "Door Actuator External Pressure Connection 175 PSI Min". If, however, a minimum 175 psi external pressure source is not available, then it becomes necessary to utilize the 3000 psi maximum storage cylinders mounted on the bulkhead. This is accomplished by removing the 3/4 OD tube assembly located between the tee and the pressure reducer, capping the tee, and installing the adapter tube assembly (which includes the 20 psi relief valve) in the reducer (AN919-20) on the pressure reducer. External source pressure is connected to the adapter tube assembly while the No. 2 solenoid valve is actuated to permit stored cylinder pressure for the ram air intake scoop doors.

Provisions for inflation-pressurization and pressure sensing of the afterbody shell or cavity (in lieu of wind tunnel ram air) have also been provided and suitably placarded.

A control box for operation of solenoid valves, ram air intake scoop doors, and squib firing is also provided. The forebody is wired to include separate electrical cables for instrumentation and for deployment and inflation operations.

The operating instructions describe in detail procedures for utilizing the equipments described above. By using low pressure external source air instead of gas in the storage cylinders, a familiarization program should be undertaken to thoroughly acquaint personnel with the various components and capabilities of the M-1-L vehicle inflation system.

Prior to any activation of the inflation-pressurization system, all plumbing must be checked to ensure a gastight system. All cylinder gas valves must be closed before removal of the gas storage cylinders for recharging and after reinstallation. The cylinder gas valves as well as the needle valves must remain closed at all times, except as noted in the instructions.

7. Inflation and Pressurization Operating Instructions

(1) Remove access door in forebody.

(2) The gas storage cylinders are removed and charged to 3000 psi maximum and reinstalled in the vehicle. NOTE: If external pressure sources are used instead of the gas storage cylinders, make modifications to the plumbing system as described in "Provisions for External Pressure".

(3) Check all fittings for gastight seals, and connect the wind tunnel ambient pressure line to 1/4 OD flared tube cross.

(4) Connect external control box to vehicle forebody cable assembly.

(5) Connect instrumentation cable to external recording oscillograph.

(6) If gas storage cylinders are used as the pressure source, open all gas cylinder valves and set the needle valves to 1/4 flow.

(7) Replace access door on forebody.

(8) Check control box to see that it is fused with 15 amp fuses. With the 28 VDC switch in "off" position, connect 28 VDC power supply to control box. NOTE: Power available must be capable of delivering surges of 28V at 22 amps.

(9) If gas storage cylinders are used as the pressure source, actuate solenoid valves through the control box switch.

(10) Actuate ram air intake scoop doors through control box switch.

SECTION VIII. OPERATION LOG

A sample copy of the M-1-L Operation Log is shown on page 28. The purpose of this log is to obtain data on the service life of the deployable-inflatable afterbody. It is requested that NASA Ames complete one of these log sheets each time the AIRMAT and/or shell is subjected to internal pressurization, and that a copy of this log be provided Goodyear Aerospace for analysis and record purposes.

In recording the log data on the configuration of afterbody prior to, during, and after the test, place a check mark under the condition of the afterbody if "packaged with cover" or "uninflated." If the afterbody is inflated, note the AIRMAT and shell pressure.

For the inflation system record the type of gas used (air, nitrogen or CO_2) and the bottle pressure or the line pressure (if factory air is used).

In recording the information on the conditions of the test, only the values resulting in maximum loading (maximum tunnel q and maximum attack angle) need be recorded. Record under "Remarks" the length of time under these maximum loading conditions.

Under the remarks column also include any changes to the configuration, such as adjustment of the internal catenary or addition of control surfaces, any severe operating conditions such as buffeting of the afterbody or pressure surges in the AIRMAT or shell, and any water accumulation in either the AIRMAT or the shell.

M-1-L OPERATION LOG

TEST NO. ______ DATE ______ PERFORMED BY: ______

TEST DESCRIPTION:

CONFIGURATION OF AFTERBODY:

	Packaged With Cover	Uninflated	Inflated (PSI) AIRMAT	Inflated (PSI) Shell
Prior to test				
During test				
After test				

INFLATION SYSTEM:

Type of gas ______

Line Pressure (PSI) ______

Bottle Pressure (PSI) ______

CONDITIONS:

Temp (^{o}F) ______ Tunnel Velocity (MPH) ______ Tunnel "q" (PSF) ______

Attack Angle ______ Yaw Angle ______ Roll Angle ______

Time:

Begin ______ End ______ Elapsed ______

REMARKS:

REFERENCES

(a) The following progress reports for the noted periods:

(1)	SP-1453	8-10-62	Thru	9-30-62
(2)	SP-1522	10-1-62	Thru	10-31-62
(3)	SP-1546	11-1-62	Thru	11-30-62
(4)	SP-1663	12-1-62	Thru	12-31-62
(5)	SP-1388	1-1-63	Thru	1-31-63
(6)	GER-11030	2-1-63	Thru	2-28-63
(7)	GER-11030A	3-1-63	Thru	3-31-63
(8)	GER-11030B	4-1-63	Thru	4-30-63
(9)	GER-11030C	5-1-63	Thru	5-31-63
(10)	SP-2084	6-1-63	Thru	6-30-63
(11)	SP-2371	7-1-63	Thru	8-15-63
(12)	SP-2592	8-16-63	Thru	10-15-63
(13)	SP-2732	10-16-63	Thru	11-15-63

(b) The following Goodyear Aerospace 62QS generated drawings:

(1) 812 Contour Bar, 54" and 36"

(2) 813 Airmat-Cross Section

(3) 814 Test Specimen, Airmat w contoured end, 3"

(4) 815 Test Specimen, Radius w Woven "X"

REFERENCES (Con't)

(b) (5) 816 Test Specimen, Radius, Catenary Intersection

(6) 817 Test Specimen, Airmat Intersection

(7) 818 Test Specimen, Woven "x" Intersection

(8) 819 Test Specimen, Airmat, Corner Development

(9) 820, Sht. 1, Rev. B, Forebody Structure, Gen. Arr

(10) 820, Sht. 2, Rev. B, Forebody Structure, Gen. Arr

(11) 820, Sht. 3, Rev. B, Forebody Structure, Gen. Arr

(12) 821, Afterbody - Fabric, Gen. Arr.

(13) 822, Sht. 1, Rev. B, Schematic Arr., Inflation System

(14) 822, Sht. 2, Rev. A, Schematic Arr., Inflation System

(15) 977, Rev. A, Support, Tunnel Fwd.

(16) 978, Rev. B, Support, Tunnel Aft.

(17) 984, Rev. A, Afterbody-Assy. and Installation

(18) 985, Rev. A, Catenary Assy. and Installation

(19) 985-103, Catenary Curtain

(20) 986, Rev. A, Airmat Top Surface, Fwd. Section

(21) 987, Rev. A, Airmat Top Surface, Aft. Section

(22) 988, Rev. A, Airmat Aft Surface, Aft. Section

(23) 989, Rev. A, Airmat Center Support

REFERENCES (Con't)

(13) 41905 Airmat, Aft Panel, Ref. a8

(14) 41906 Forebody, Bottom Part, Ref. a8

(15) 52447 Afterbody & Forebody, 3/4 aft stbd,, Ref. a9

(16) 52448 Afterbody & Forebody, Starboard, Ref. a9

(17) 52449 Forebody, Starboard Side, Ref. a9

(18) 52450 Forebody, Aft View, Ref. a9

(19) 52451 Forebody, 3/4 Aft Starboard, Ref. a9

(20) 52849 Afterbody/Forebody, Assy, in Process, Ref. a9

(21) 52850 Afterbody/Forebody, Catenary Intersect, Ref. a9

(22) 52851 Afterbody, Catenary, Forebody, Intersect, Ref. a9

(23) 52852 Afterbody/Forebody, Assy. in Process, Ref. a9

(24) 52901 Afterbody, 25 psi Operating Pressure, Ref. a9

(25) 52902 Afterbody, 37.5 psi Proof Pressure, Ref. a9

(26) 61025 Aft View, Ref. a10

(27) 61025 3/4 Aft Starboard, Ref. a10

(28) 70803 Airmat, Failure, Ref. a10

(29) 70804 Airmat, Failure, Ref. A10

(30) 91202, Pillow Test - 2 Airmat, Ref. a12

REFERENCES (Con't)

(24) 990, Rev. A, Airmat, Fin

(25) 991, Fabric Shell

(26) 992, Rev. A, Nose, Forebody Structure

(27) 993, Test Specimen, Airmat, Fin Intersection

(28) 994, Valve Spud Assy,

(c) GAC Dwg. 63QS009, Casting

(d) GAC Dwg. 63QS010, Casting

(e) The following A630 Series photographs were taken as documentation for the fabrication and test effort and were included in the referenced reports.

(1) 22508 Airmat, Fin Fabrication, Ref. a6

(2) 22509 Airmat, Aft Panel, Ref. a6

(3) 22510 Airmat, Top Aft Fabr., Ref. a6

(4) 22511 Airmat, Int. Fin Fabr., Ref. a6

(5) 31133, Fin Intersect Test, Ref. a7

(6) 31134, Fin Intersect Test, Ref. a7

(7) 31135, Fin Intersect Test, Ref. A7

(8) 32501 Forebody Frame, 3/4 top view, Ref. a7

(9) 32502 Forebody Frame, 3/4 Bottom View, Ref. a7

(10) 41902 Forebody Top Starboard, Ref. a8

(11) 41903 Airmat, Catenary, Ref. a8

(12) 41904 Airmat, Internal Fin, Ref. a8

REFERENCES (Cont'd)

A640 Series

(31) 11459 Static Test

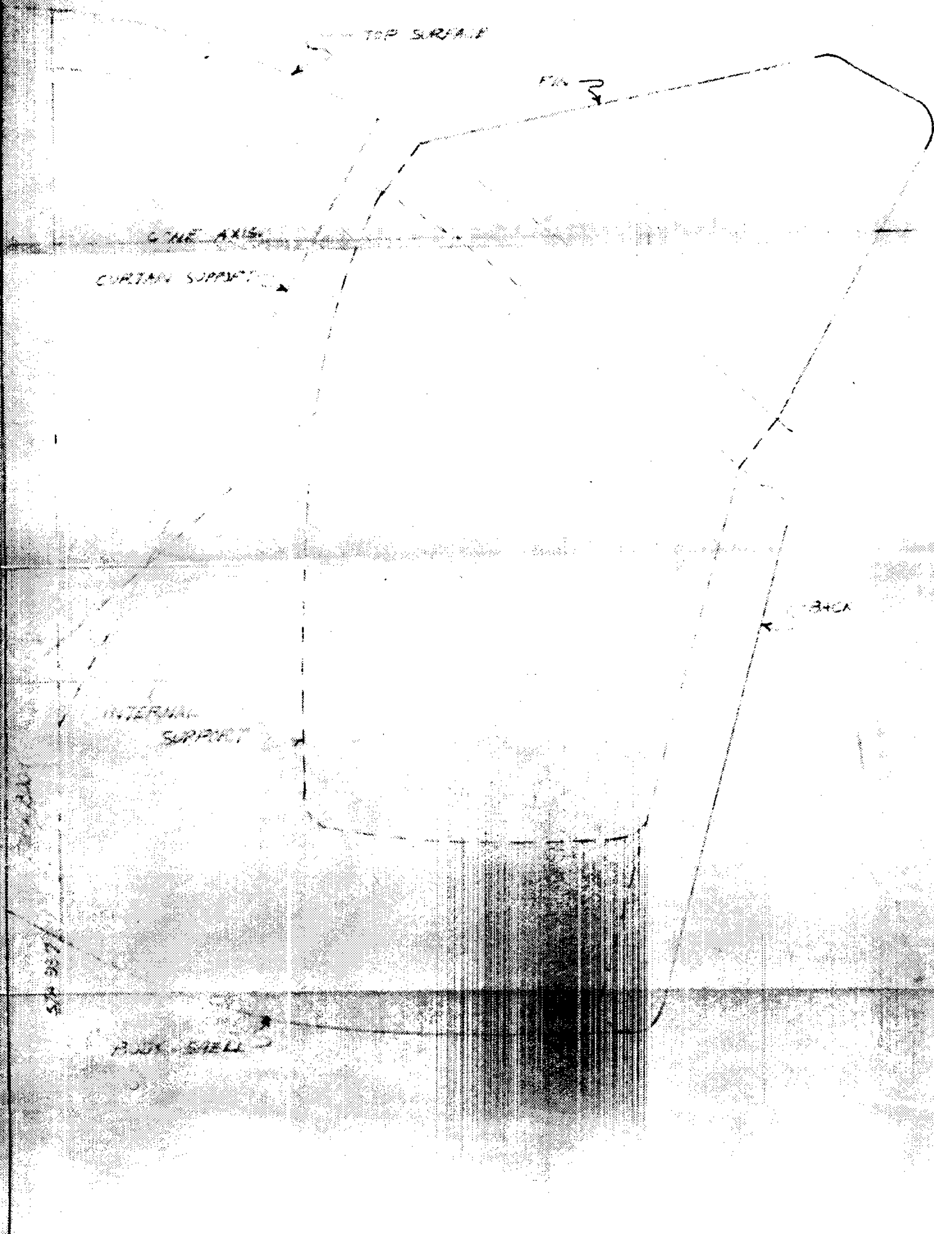
(32) 11460 Static Test

(33) 11615 Scoop-Door Check

(34) 11616 Scoop-Door Check

(35) 11618 Packaged for Deployment

M-1-L FABRIC AFTERBODY SKETCH



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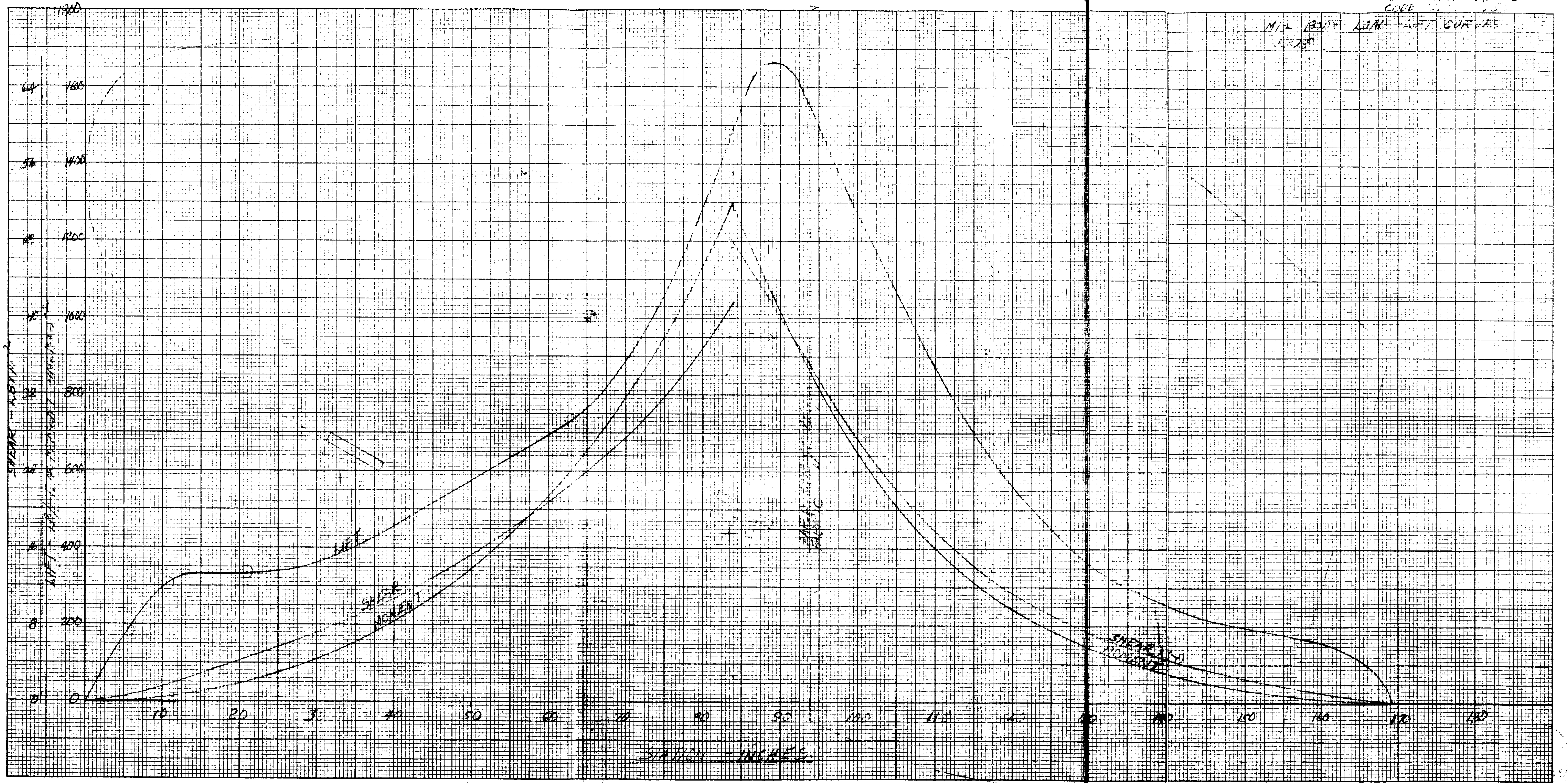
M/L BODY LOAD - LIFT CURVES
SHEAR - LB
LIFT
SHEAR
MOMENT
SHEAR
MOMENT
STATION - INCHES
0
200
400
600
800
1000
1200
1400
1600
1800
8
16
24
32
40
48
56
64
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MODEL M-1L
GER- 11141 - APP. B
REF NO. 25500

JR 221 (2-60)

GER-11141, APPENDIX A

M-1-L WIND TUNNEL MODEL

(FULL SCALE)

CONTRACT SPECIFICATION

NAS2-1037

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AMES RESEARCH CENTER

MOFFETT FIELD, CALIFORNIA

SPECIFICATIONS FOR AN M-1 LIFTING RE-ENTRY

BODY WITH AN INFLATABLE AFTERBODY

Specification No. NAS2-1037 August 13, 1962

1. The Contractor shall design, engineer, and fabricate a body conforming to the contoured shape of the M-1 Lifting Re-entry Body and an inflatable afterbody capable of attachment to the M-1 body. These bodies shall be contoured to the shapes shown in Ames Drawing No. A-12059D-1, attached.

2. The M-1 body shall be constructed to withstand air loads of 100 psf plus the accompanying loads transferred from the inflatable afterbody at this same condition for angles of attack of the body from 0° to 30°. These loads shall include the dynamic loads accompanying afterbody deployment from the uninflated, stowed position to the fully inflated position.

3. The M-1 body shall incorporate suitable attachment hard points compatible with the mounting systems in the Ames 40- by 80- Foot Wind Tunnel. Ames approval of the attachment design is required before fabrication is begun. The attachment shall be capable of withstanding the loads mentioned in paragraph 2 above with a safety factor of 3.0.

4. The M-1 body shall be capable of stowing the uninflated afterbody within the heat shield and of deploying the afterbody after jettison of the heat shield fairing at dynamic pressures up to 100 psf.

5. The afterbody shall be constructed from elastomer-impregnated fabric. The upper contoured surfaces shall be constructed of "Airmat" with sufficient strength to retain its shape at dynamic pressures up to 100 psf. The lower surfaces shall be of single thickness, elastomer-impregnated fabric.

6. The "Airmat" surfaces shall be inflated from a high-pressure gas storage system which shall be incorporated in the M-1 body and be capable of remote operation.

7. The remainder of the body shall be inflated by ram-air from the air stream. The ram-air inlets shall be designed as integral parts of the afterbody.

NAS2-1037 August 13, 1962

8. The afterbody shall be equipped with suitable attachment points for either rigid or inflatable control surfaces atop and to the rear of the body at two locations on each side, 50-inches out from the centerline. Provision shall be made for both vertical and horizontal surfaces at each location. An attachment point for the horizontal surface shall also be provided on the body centerline. These attachment points shall have structure capable of supporting the loads transferred from the control surfaces at operating conditions up to dynamic pressures of 100 psf with minimum deflection of the supporting structure.

9. The heat shield fairing on the M-1 body shall be capable of remotely controlled jettison. The fairing shall be recoverable without damage to it or the Wind Tunnel.

10. The afterbody deployment and inflation system shall be tested statically and proved by the Contractor prior to shipment to Ames Research Center.

GER 11141 -APPENDIX B

M-1L WIND TUNNEL MODEL
(FULL SCALE)

DESIGN ANALYSIS

CONTENTS

INTRODUCTION

THE WIND TUNNEL MODEL (FULL SCALE) OF THE M-1-L VEHICLE CONSISTS OF A HARD FOREBODY OF WOOD AND ALUMINUM AND AN INFLATED AFTER-BODY OF FABRIC AND "AIRMAT". THE FOREBODY CONFORMS TO THE M-1-L BODY CONTOURS AND PROVIDES ATTACH POINTS TO MATE WITH THE TUNNEL MOUNTING SYSTEM. THE FABRIC AFTER-BODY IS CAPABLE OF DEPLOYMENT IN THE TUNNEL WHILE THE MODEL IS SUBJECT TO DYNAMIC PRESSURE.

THE INCLUDED ANALYSIS SHOWS THE FORE-BODY MOCK UP HAS SUFFICIENT STRENGTH TO WITHSTAND LOADS IMPOSED BY THE USE OF THE MODEL IN THE TUNNEL AT THE STATED DYNAMIC PRESSURES. THE FABRICS ARE STRONG ENOUGH TO CARRY THE STRESSES IMPOSED BY INFLATION AND THE STEADY STATE AIRLOADS WITH AMPLE FACTORS OF SAFTEY. STIFFNESS CRITERIA IS NOT WELL DEFINED. THE DESIGN ATTEMPTS TO PROVIDE AS MUCH STIFFNESS AS IS PRACTIC-ABLE WITH AN INFLATED STRUCTURE OF REASONABLE WEIGHT.

DEPLOYMENT LOADS ARE OTHER QUANTITIES WHICH CANNOT BE WELL DEFINED AT THIS TIME. THESE POSSIBLE LOADS ARE PROVIDED FOR BY BUILDING THE ATTACHMENTS BETWEEN THE HARD STRUCTURE AND THE FABRIC MUCH STRONGER THEN THE STEADY STATE AIRLOADS REQUIRE. COMPLETION OF THE WIND TUNNEL TESTS MAY PROVIDE BETTOR DEFINATION OF THE DEPLOYMENT LOADS. THUS A REVIEW OF THE STRENGTH OF THE CONNECTIONS BETWEEN THE FABRIC AND HARD STRUCTURE MAY BE REQUIRED.

THIS REPORT DOES NOT CONSTITUTE A COM-PLETE DETAIL STRESS ANALYSIS OF THE BODY,

BUT SHOWS OVERALL STRENGTHS ARE ADEQUATE. ANALYSIS OF DETAIL PARTS CONSIDERED CRITICAL ARE INCORPORATED IN THIS REPORT.

FOREBODY ANALYSIS

THE SHEAR AND BENDING OF THE FOREBODY DUE TO THE LIFT ARE CONSERVATIVELY CALCULATED. THE FOREBODY STRUCTURE CONSISTS OF WOOD FRAMES AND STRINGERS WITH ALUMINUM ALLOY SKINS BONDED TO THEM. IT IS CONSERVATIVELY ASSUMED THAT THE ALUMINUM ALLOY SKINS CARRY ALL THE FORE AND AFT LOAD COMPONENTS. SINCE A SKIN BUCKEL WOULD PROBABLY PACCIPITATE A COMPLETE FAILURE OF THE BONDS, THE INITIAL BUCKLING STRESSES, COMPRESSION AND SHEAR, ARE DETERMINED FOR THE LARGEST FLAT PANEL AND USED AS THE ALLOWABLE STRESSES. THESE STRESSES ARE CONVERTED TO ALLOWABLE SHEAR LOADS AND MOMENTS ON THE VARIOUS SECTIONS OF THE FOREBODY.

THE FOREBODY IS CONSIDERED SAFE SINCE THE MARGINS OF THE BUCKLING LOADS OVER THOSE CALCULATED ARE LARGE. THE BENDING MOMENT AT ANY SECTION IS NOT ACCURATELY KNOWN. BECAUSE THE DRAG HAS AN APPRICIABLE CONTRIBUTION TO THE MOMENT. IN THE LIGHT OF THE LARGE MARGINS FOR THE CALCULATED MOMENTS IT IS NOT DEEMED NECESSARY TO MORE ACCURATELY DEFINE THE APPLIED MOMENTS.

THE FACTOR OF SAFTEY OF THREE SPECIFIED FOR THE TUNNEL ATTACH POINTS IS CARRIED THROUGH THE FOREBODY FITTINGS WHICH MATE WITH THE TUNNEL SUPPORTS AND THIER ATTACHMENT TO THE FOREBODY STRUCTURE.

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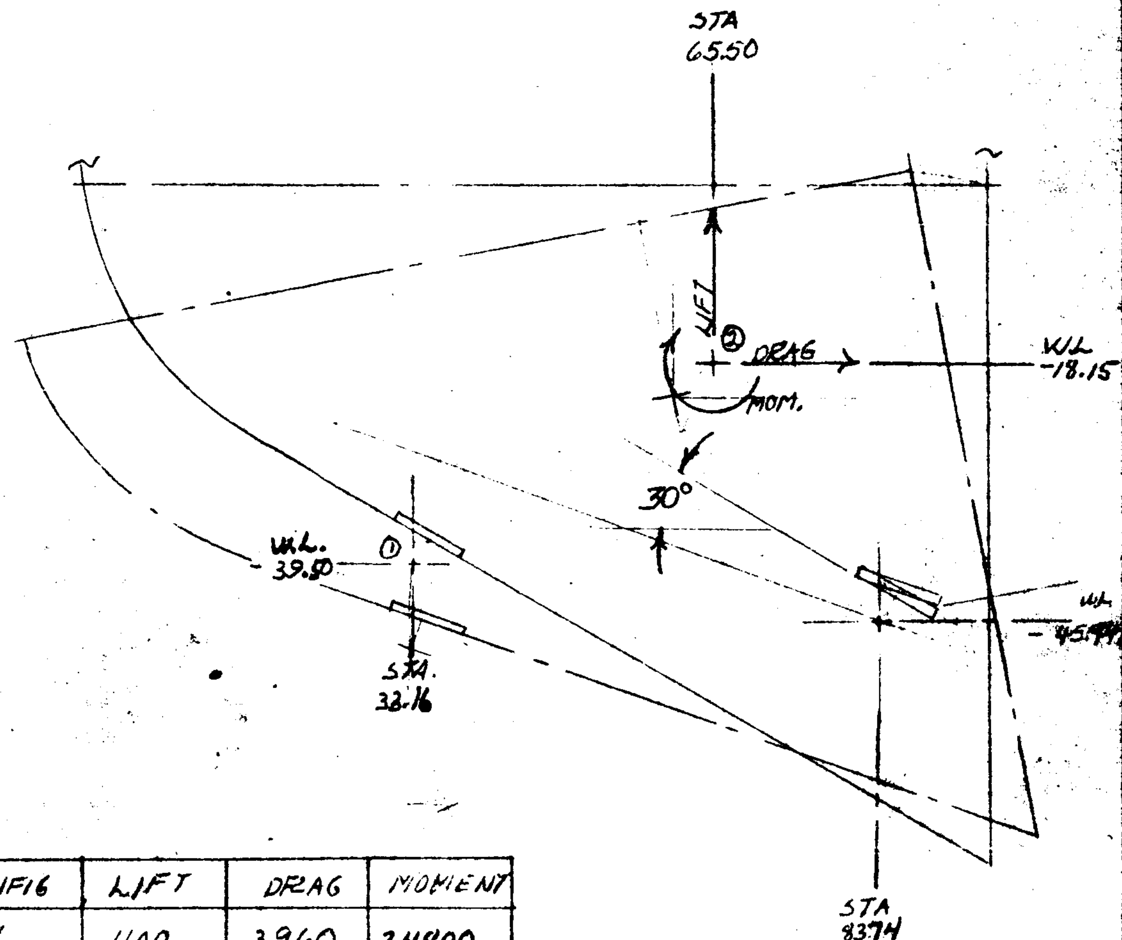
GOODYEAR AIRCRAFT

TUNNEL SUPPORT LOADS.



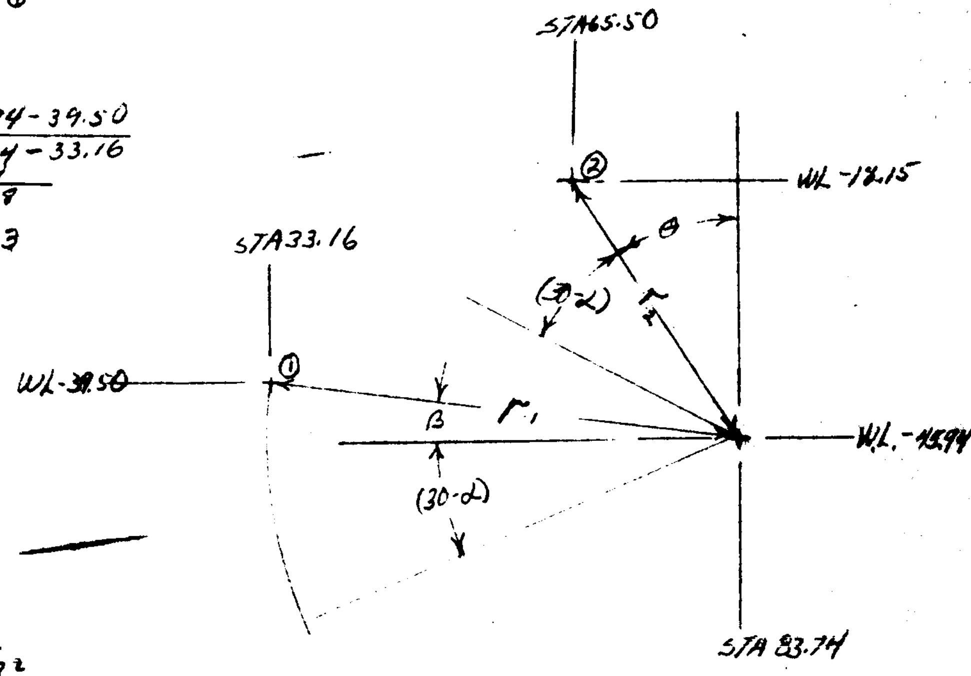
α	CONFIG	LIFT	DRAG	MOMENT
20	M1	1100	3960	24800
30	M1	2860	4450	53000
20	M1-L	7700	2260	-128800
30	M1-L	11800	4000	-212500

ASSUME THE DRAG FORCE IS REACTED BY THE AFT SUPPORTS. ASSUMING THE ℄ OF THE BALL FITTING TO BE 3 INCHES AWAY FROM THE MOUNTING PLATES PLACES THE TWO AFT SUPPORTS AT STA 83.74 AND W.L. -45.94. THE FORWARD SUPPORT HINGE POINT IS AT W.L. -39.50 AND STA. 33.16. THE FORWARD SUPPORT IS ASSUMED TO BE VARIED IN LENGTH AND TO REMAIN NORMAL TO THE TUNNEL FLOOR.

TUNNEL SUPPORT LOADS.

$$\theta = \text{ARCTAN}\ \frac{83.74-65.50}{45.94-18.15}$$
$$= \text{ARCTAN}\ \frac{18.24}{27.79}$$
$$= \text{ARCTAN}\ .656$$
$$\underline{\theta = 33.3^{0}}$$

$$\beta = \text{ARCTAN}\ \frac{45.94-39.50}{83.74-33.16}$$
$$= \text{ARCTAN}\ \frac{6.44}{50.58}$$
$$= \text{ARCTAN}\ .1273$$
$$= \underline{7.3^{0}}$$



$$r_1 = \sqrt{6.44^2 + 50.58^2}$$
$$= \sqrt{41.5 + 2558}$$
$$= \underline{51.0\ IN.}$$

$$r_2 = \sqrt{18.24^2 + 27.79^2}$$
$$= \sqrt{333 + 772}$$
$$= \underline{33.2\ IN}$$

$$x_1 = r_1 \cos(30-\alpha-\beta)$$
$$= \underline{51.0 \cos(22.7-\alpha)}$$

$$x_2 = 33.2\ \sin(\theta + 30 - \alpha)$$
$$= \underline{33.2\ \sin(63.3-\alpha)}$$

$$y_2 = 33.2\ \cos(\theta + 30 - \alpha)$$
$$= \underline{33.2\ \cos(63.3-\alpha)}$$

$$R_1 = \frac{M + L x_2 + D y_2}{x_1}$$

$$R_{2VL} = R_{2VR} = \frac{L - R_1}{2}.$$

$$R_{2HL} = R_{2HR} = \frac{D}{2}.$$

R_1 - FWD TUNNEL REACTION

R_{2V} - AFT TUNNEL VERT REACTION

R_{2H} - AFT TUNNEL HORIZ REACTION

L, R, - LEFT AND RIGHT.

TUNNEL SUPPORT LOADS

M-1 CONFIG $\alpha = 20^0$

$$R_1 = \frac{24800 + 1100(33.2 SIN 43.3) + 3960(33.2 COS 43.3)}{51.0(COS\ 2.7)}$$

$$= \frac{24800 + 25000 + 95700}{50.9}$$

$= 2860$ LB.

$$R_{2VL} = R_{2VR} = \frac{1100 - 2860}{2}$$
$$= -880 LB$$

$$R_{2HL} = R_{2HR} = \frac{3960}{2}$$
$$= 1980 LB$$

M-1 CONFIG $\alpha = 30^0$

$$R_1 = \frac{53000 + 2860(33.2) SIN 33.3 + 4450(33.2)(COS 33.3)}{51.0\ COS(-7.3)}$$

$$= \frac{53000 + 52100 + 123500}{50.6}$$

$= 4520$ LB

$$R_{2VL} = R_{2VR} = \frac{2860 - 4520}{2}$$
$$= -830\ LB$$

$$R_{2HL} = R_{2HR} = \frac{4450}{2}$$
$$= 2225\ LB$$

TUNNEL SUPPORT LOADS

M-1-L CONFIG. $\alpha = 20^0$

$$R_1 = \frac{-128800 + 7700(33.2)\,SIN\,43.3 + 2260(33.2)\,COS\,43.3}{50.7}$$

$$= \frac{-128800 + 175300 + 54600}{50.7}$$

$$= 1990\ LB$$

$$R_{2VL} = R_{2VR} = \frac{7700 - 1990}{2}$$
$$= 2855\ LB$$

$$R_{2HL} = R_{2HR} = \frac{2260}{2}$$
$$= 1130\ LB$$

M-1-L CONFIG $\alpha = 30^0$

$$R_1 = \frac{-212500 + 11800(33.2)\,SIN\,33.3 + 4000(33.2)\,COS\,33.3}{50.6}$$

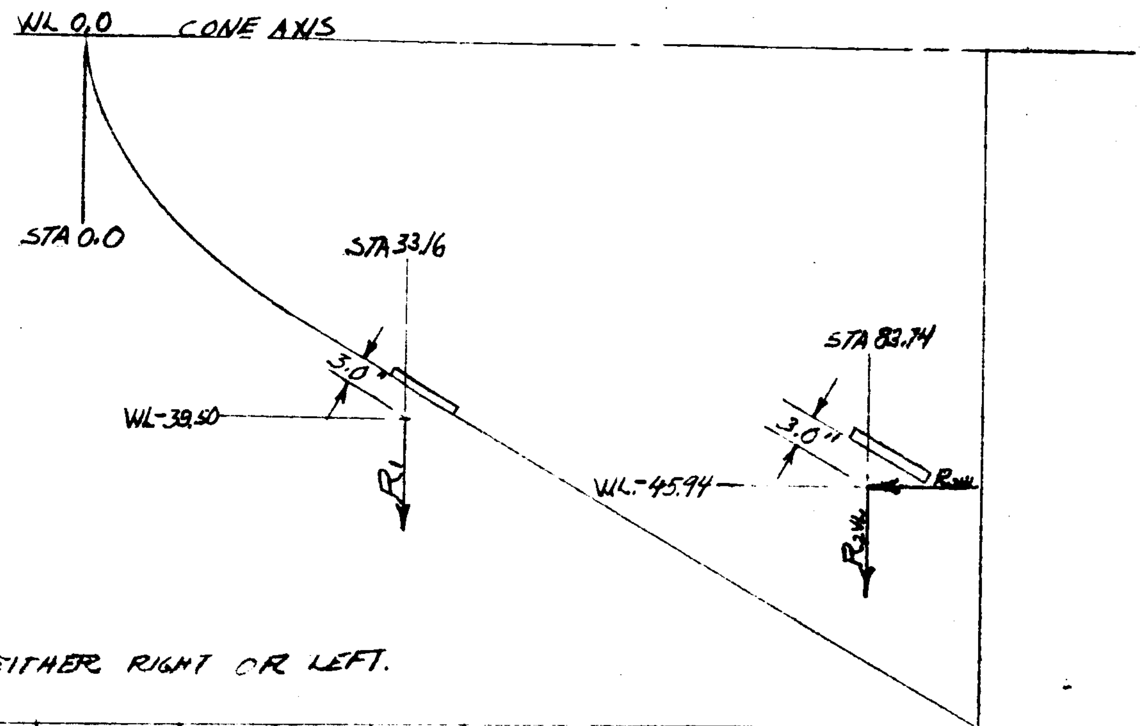
$$= \frac{-212500 + 215100 + 111000}{50.6}$$

$$= 2250\ LB$$

$$R_{2VL} = R_{2VR} = \frac{11800 - 2250}{2}$$
$$= 4775\ LB$$

$$R_{2HL} = R_{2HR} = \frac{4000}{2}$$
$$= 2000\ LB$$

TUNNEL SUPPORT LOADS
SUMMARY



i EITHER RIGHT OR LEFT.

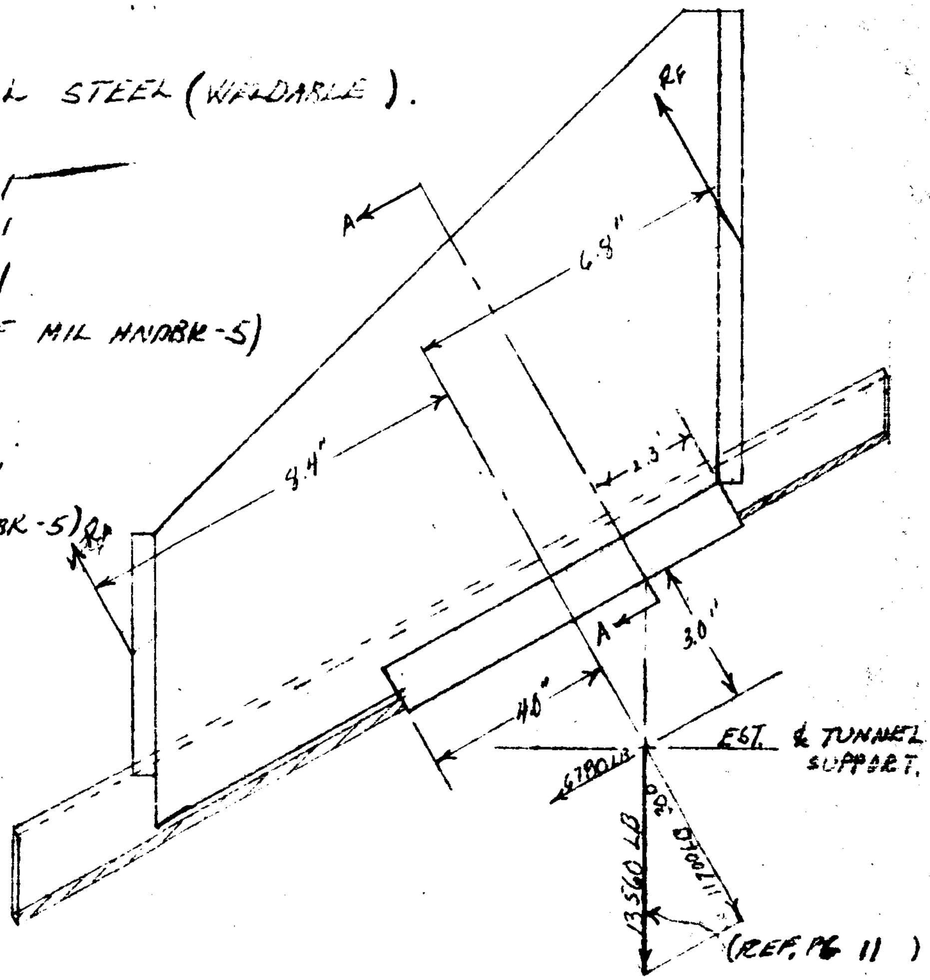
α	CONFIG	R_1	$3R_1$	R_{2Vi}	$3R_{2Vi}$	R_{2Hi}	$3R_{2Hi}$
20	M-1	2860	8580	-880	-2640	1980	5940
30	M-1	4520	13560	-830	-2490	2225	6675
20	M-1-L	1990	5970	2855	8565	1130	3390
30	M-1-L	2250	6750	4775	14325	2000	6000

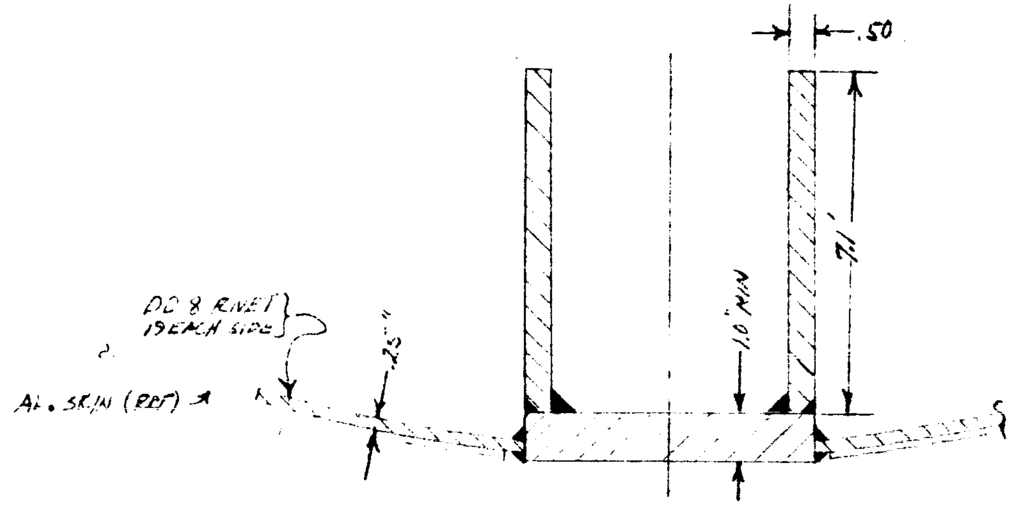
FORWARD TUNNEL SUPPORT
(REF DWG 6295977)

MATERIAL
COMMERCIAL STEEL (WELDABLE).

F_{tu} = 55000 PSI
F_{ty} = 36000 PSI
F_{su} = 35000 PSI
(REF MIL HNDBK-5)

WELD AREAS
F_{tu} = 57000 PSI
F_{su} = 32000 PSI
(REF MIL-HDBK-5)





SECTION A-A

FORWARD TUNNEL SUPPORT (CONT)

THE FORWARD REACTION "R_F". (REF PG. 12)

$$R_F = \frac{(8.4)(11700)+(3)(6780)}{8.4+6.8}$$

$= 6460 + 1340$
$= 7800$ LB.

THE AFT REACTION "R_A". (REF PG. 12)

$= 11700 - 6460 - 1340$
$= 3900$ LB.

THESE REACTIONS ARE RESOLVED INTO A SHEAR ALONG THE FACE PLATES AND A NORMAL FORCE.

$R_{F(S)} = 7800 (\cos 30^\circ)$
$= 6770$ LB.
$R_{F(N)} = 7800 (\sin 30^\circ)$
$= 3900$ LB.

$R_{A(S)} = 3900 (\cos 30^\circ)$
$= 3380$ LB.
$F_{A(N)} = 3900 (\sin 30^\circ)$
$= 1950$ LB.

16 - ½" BOLTS CARRY THE SHEAR AND A BEARING AREA OF 10 X 9.75 CARRIES THE NORMAL FORCE OF FORWARD ~~REACTION~~. (REF DWG 62QS 977, 62QS 820 SHT2)

$P_{BOLT} = \frac{6770}{16}$
$= 423$ LB.

$f_{BE} \cong \frac{3900}{97.5}$
$\cong 40$ PSI.

8 - ½ BOLTS CARRY THE SHEAR AND A BEARING AREA OF 10 X 5.00 CARRIES THE NORMAL COMPONENT OF AFT REACTION. (REF DWGS. 62QS 977, 62QS 820 SHT2)

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FORWARD TUNNEL SUPPORT (CONT)

THE BOLTS ARE CRITICAL IN BEARING ON MAHOGANY FRAME MEMBER. THE FRAME IS CONSTRUCTED OF NOMINAL 2 IN LUMBER

F_{BR} = 1400 PSI (REF. PG. C8.2, AIRPLANE STRUCTURAL DESIGN BY E.F. BRUHN 1942 EDITION)

$$P_{BOLT} = (.5)(1.63)(1400)\left(\tfrac{1}{2}\right)^{*}$$
$$= 570 \text{ LB.}$$

* THE BOLTS ARE LOADED AT ONE END ONLY. THE REF. INDICATES THE ALLOWABLE LOAD IS REDUCED BY A FACTOR 2 FOR THIS CONDITION.

$$M.S. = \frac{570}{423} - 1 \quad \text{(REF. PG. 13)}$$
$$= .35$$

BEARING OF PLATE ON WOOD.

$$M.S. = \frac{1400}{40} - 1 \quad \text{(REF. PG. 13)}$$
$$= \text{HIGH}$$

JR-218 (7-61)M
REF: ENGRG PROCEDURE S-017

FWD TUNNEL SUPPORT (CONT.)

SECTION. A-A.

THE BENDING SECTION IS CONSERVATIVELY ASSUMED TO CONSIST OF THE 2 $\frac{1}{2}''$ PLATES.

$$Z = 2\ \frac{(7.1)^2(.5)}{6}$$

$$= 8.40\ IN^3 \quad \text{(REF PG. 12)}$$

$$M = 7800(6.8 - 4.0 + 2.3)$$

$$= 39800\ IN\ LB$$

$$f_b = \frac{39800}{8.40}$$

$$= 4750\ PSI.$$

$$M.S. = \frac{36000}{4750} - 1 = \underline{HIGH} \quad \text{(REF. PG 12)}$$

IT IS ASSUMED THAT THE 6780 LB COMPONENT OF LOAD IS CARRIED IN SHEAR BY THE WELD TO THE .25 IN PLATE. THE 11700 LB COMPONENT IS CARRIED IN TENSION BY WELDS TO $\frac{1}{2}''$ PLATES.

$$f_s = \frac{6780}{2(8)(2)(.25)(.707)} \quad \text{(REF PG. 12)}$$

$$= 1200\ PSI.$$

$$\underline{M.S. = \frac{32000}{1200} - 1 = HIGH.}$$

$$f_t = \frac{11700}{2(8)(.25 + .707 \times .5)}$$

$$= 1220\ PSI \quad \text{(REF PG. 12)}$$

$$\underline{M.S. = \frac{51000}{1220} - 1 = HIGH}$$

OTHER AREAS OF THE FITTING ARE SAFE BY INSPECTION.

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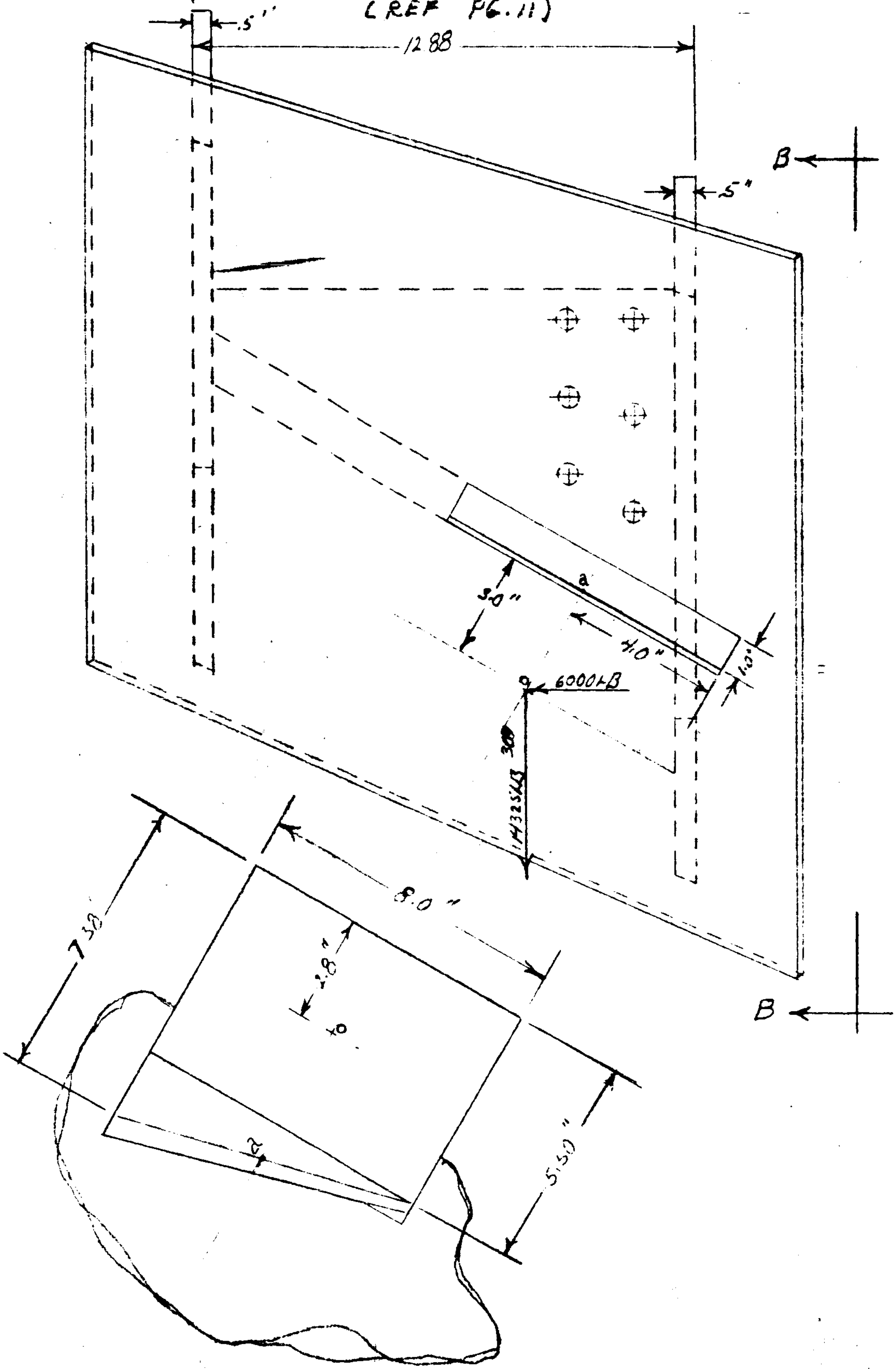
AFT TUNNEL SUPPORT

(REF. DWG. 62QS 978)
(REF PG. 11)



JR-218 (7-61)M
REF ENGRG PROCEDURE S-017

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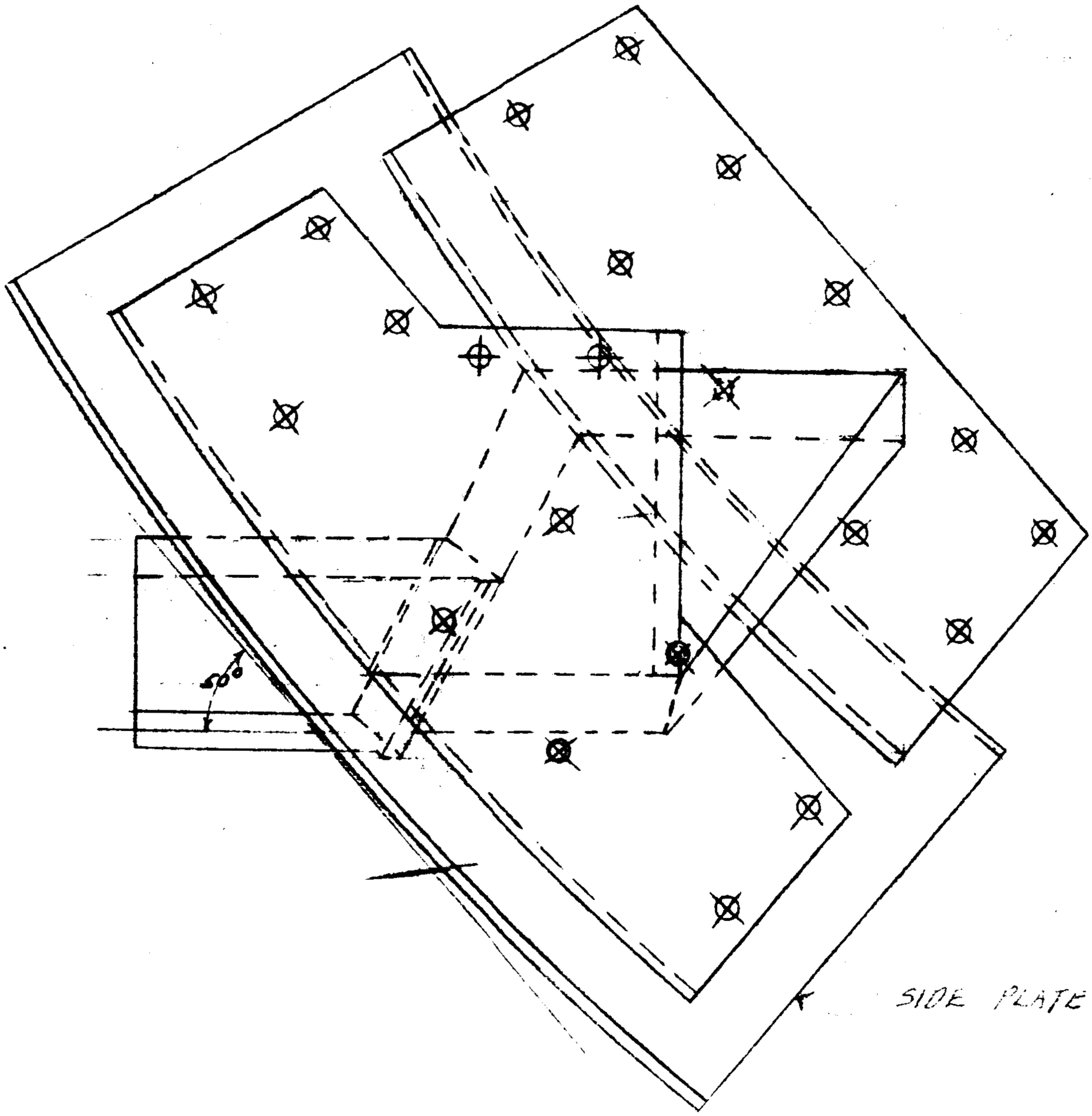
AFT TUNNEL SUPPORT (CONT.)



VIEW B-B (REF PG 16)

JR-218 (7-61)M
REF. ENGRG PROCEDURE S-017

AFT TUNNEL SUPPORT (CONT.)

THE FORCES AT POINT O ARE RESOLVED INTO A FORCE NORMAL TO THE MOUNTING SURFACE AND A FORCE PARALLEL TO THIS SURFACE.

$P_N = 14325 \cos 30^0 + 6000 \sin 30^0$
$= 12400 + 3000$
$= \underline{15400 \text{ lb}}$ (REF PG 16)

$P_S = 6000 \cos 30^0 - 14325 \sin 30^0$
$= 5190 - 7163$
$= \underline{-1970 \text{ LB}}$ (REF PG 16)

BENDING CHECK AT END OF MACHINE CUT
(REF PG.16

$M_X = (15400)(5.50 - 2.8)$
$= 41600$ IN. LB.

$M_Y = 1970(5.50 - 2.8)$
$= 5320$ IN. LB.

$Z_{XX} = \frac{8.0(1.0)^2}{6}$
$= 1.33 \text{ in}^3$

$Z_{YY} = \frac{1.(8.0)^2}{6}$
$= 10.7 \text{ in}^3$

$S_{b\,max} = \frac{41600}{1.33} + \frac{5320}{10.7}$
$= 31300 + 500$
$\cong 32000$ PSI.

THE 1" PLATE IS 4130 STL COND N.
$F_{CY} = 70000$ PSI.

$M.S = \frac{70000}{32000} - 1 = \underline{1.19}$

AFT TUNNEL SUPPORT (CONT)

TORQUE ON THE SECTION AT END OF MACHINE CUT

$T = 1970 \times 3$
$= 5910$ IN-LB (REF PP 16 & 18)

$f_s = \frac{3T}{bt^2}$

$= \frac{3(5910)}{8(1)^2}$

$= \underline{2220 \text{ psi}}$

$F_{su} = 55000$ PSI

M.S. = HIGH.

ATTACHMENTS

THE MOMENT ABOUT THE LONGITUDINAL AXIS IS ASSUMED TO BE REACTED BY A COUPLE BETWEEN INTERSECTION OF SIDE PLATE AND EAR AND ATTACHMENT TO VERTICAL PLATE. THE REMAINING FORCES AND MOMENTS ARE TRANSFERRED TO THE INTERSECTION OF SIDE PLATE AND EAR. THESE ARE RESOLVED INTO THE TANGENTIAL AND RADIAL COMPONENTS. THE TANGENTIAL COMPONENTS ARE REACTED BY

AFT TUNNEL SUPPORT (CONT)

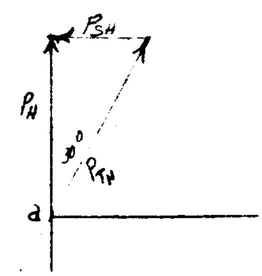
ATTACHMENTS (CONT)

THE RIVETS ATTACHING SIDE PLATE TO SKIN AND THE RADIAL COMPONENTS ARE REACTED BY THE BOLTS ATTACHING END PLATES TO THE MAHOGANY FRAMES (REF PP 16 & 17)

M_X — MOMENT ABOUT LONGITUDINAL AXIS.

$$M_X = (14325)\left(\frac{2.38+5.50}{2} - 2.8\right)$$
$$= 52100 \text{ IN. LB}$$

$$P_V' = \frac{52100}{(7-.94)} \quad \text{(REF DWG. 62 OS 978)} \quad \frac{2.38-5.50}{2} = .94$$
$$= 8600 \text{ LB.}$$



$$P_V = 8600 + 14325$$
$$= 22925 \text{ LB.}$$

$$P_H = 6000 \text{ LB}$$

$$M_Z = 6000\left(\frac{2.38+5.50}{2} - 2.8\right)$$
$$= 21800 \text{ IN. LB.}$$

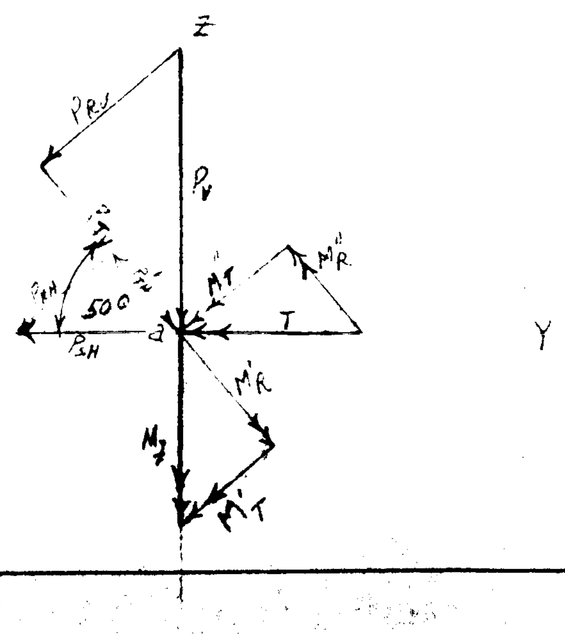
$T =$ [illegible] (REF [illegible])

$$P_{SH} = 6000\,(\text{TAN}\,30^0)$$
$$= 3460 \text{ LB. (OUT)}$$

$$P_{RH} = 3460\,(\text{SIN}\,50^0)$$
$$= 2650 \text{ LB}$$

$$P_{RV} = 22925\,(\text{COS}\,50^0)$$
$$= 14800 \text{ LB}$$

$$P_R = (14800 + 2650) = \underline{(17450)} \text{ LB.}$$



AFT TUNNEL SUPPORT (CONT)

ATTACHMENTS (CONT)

$P_{TH} = \frac{6000}{\cos 30°}$
$= \underline{6940}$ LB.

$P_T = (22925)(\sin 50°) - (3460)(\cos 50°)$
$= \underline{15400}$ LB.

$M'_T = (21800)(\cos 50°)$
$= 14000$ IN.LB.

$M''_T = 5910\ (\sin 50°)$
$= 4530$ IN.LB

$M_T = \underline{18530}$ IN.LB.

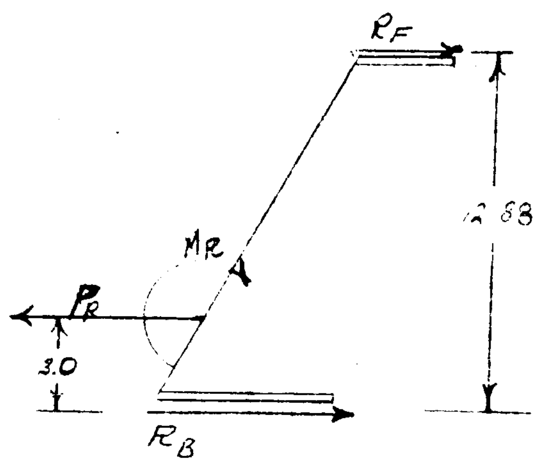
$M'_R = (21800)(\sin 50°)$
$= 16700$ IN.LB.

$M''_R = (5910)(\cos 50°)$
$= 3800$ IN.LB.

$M_R = 16700 - 3800$
$= 12900$ IN.LB.

$R_B = \frac{12.88 - 3.0}{12.88} 17450 + \frac{12900}{12.88}$
$= 13400 + 1000$
$= \underline{14400}$ LB

12 - $\frac{9}{16}$ IN. BOLTS AND
8 $\frac{1}{4}$ IN. BOLTS CARRY R_B
(REF DWG 1195120 SHT 2)



THE BOLTS BEAR ON WOOD IN RADIAL DIRECTION. THE WOOD GRAIN IS HORIZONTAL. THE ALLOWABLE BOLT LOAD IS FOUND BY DETERMINING THE LEAST

AFT TUNNEL SUPPORT (CONT.)

ATTACHMENTS (CONT.)

RESULTANT PERMITTED BY BEARING ALLOWABLES FOR LOADS PARALLEL AND PERPENDICULAR TO THE GRAIN.

PERPENDICULAR TO GRAIN

$F_{BR} = 1400$ PSI. (REF. AIRPLANE STRU. DESIGN, BRUHN)

ALONG RADIAL LINE.

$F_{BR} = \frac{1400}{\cos 50} = 2180$ PSI.

PARALLEL TO GRAIN

$F_{BR} = 5700$ PSI. (REF. AIRPLANE STRU. DESIGN, BRUHN)

ALONG RADIAL LINE

$F_{BR} = \frac{5700}{\sin 50} = 7440$ PSI

ALLOWABLE RADIAL LOAD

$P = \frac{1}{2}\left[\frac{9}{2} \times 1.625 \times 12 + \frac{1}{4} \times 1.625 \times 5\right] 2180$

$= 15500$ LB

$M.S. = \frac{15500}{14400} - 1 = .07$

AFT TUNNEL SUPPORT (CONT.)

ATTACHMENTS (CONT.)

THERE ARE 23 DD 5 RIVETS IN SINGLE SHEAR ALONG THE 24.62 INCH EDGE OF THE PLATE WHERE q_{MAX} OCCURS. (REF PG 23) (REF DWG 62 03 820 SHT 2)

$$P_{RIV} = \frac{24.62 \cdot 15}{23}\, 424$$
$$= 426 \text{ LB.}$$

$P_{ALL} = 1640$ LB (REF. MIL HDBK 5. PG. 8.1.1.1.2)

$$M.S. = \frac{1640}{426} - 1 = \underline{\underline{HIGH}}$$

AFT TUNNEL SUPPORT FITTING (CONT)

ATTACHMENTS (CONT)

$R_F = 17450 - 13400 + 1000$ (REF PG. 21)
$= 3050$ LB

10-$\frac{1}{2}$ IN BOLTS CARRY THIS LOAD. (REF DWG 6295820, SH 2)

$P = (570)(10)$ (REF PG. 14)
$= 5700$ LB

$M.S = \frac{5700}{3050} - 1 = \underline{.86}$

$\bar{l}$ = DISTANCE FROM RIGHT EDGE TO CENTROID OF AREA.

$\bar{l} = \frac{21.06}{3}\left(\frac{4200 + 24.62}{21 + 24.62}\right)$
$= 10.25$ IN.

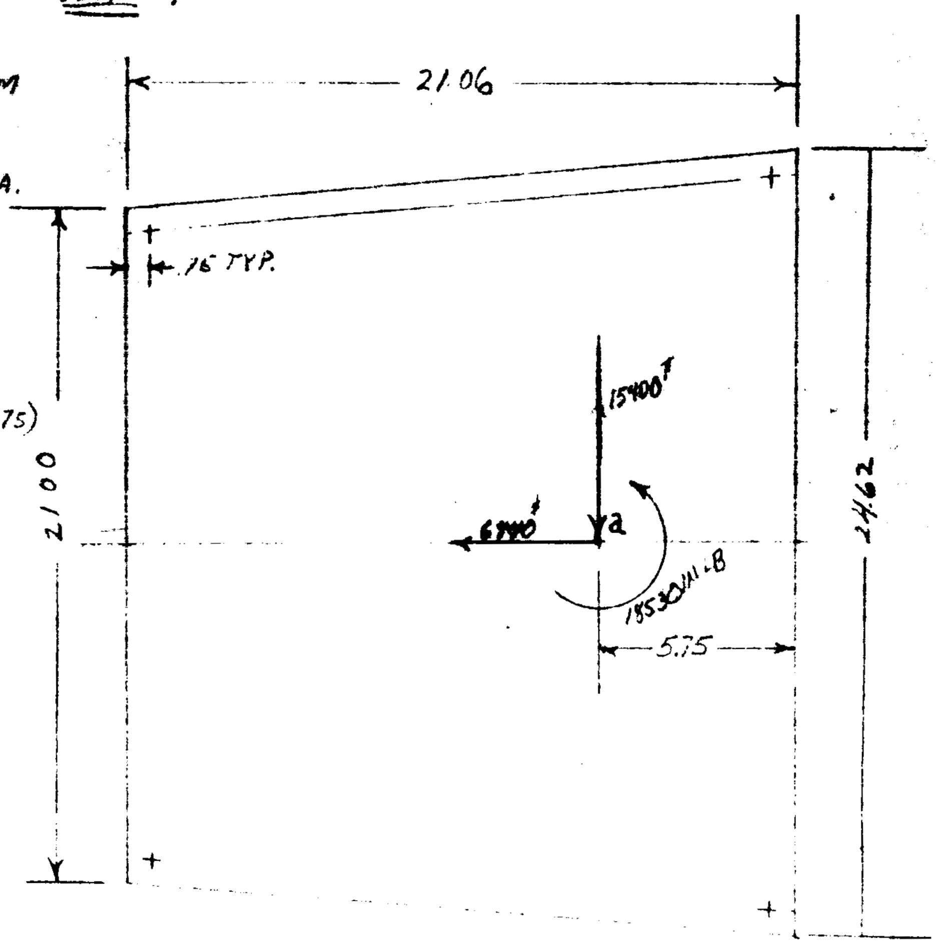
$T = 18530 + 15400(10.25 - 5.75)$
$= -50770$ IN.LB.

THE SHEAR FLOW AROUND THE RIVET PATTERN IS CALCULATED.

$q_{V(AVG)} = \frac{15400}{23.12 + [illegible]}$
$= 363$ LB/IN

$q_T = \frac{50770}{2\left(\frac{23.12 + 19.50}{2}\right)19.56}$
$= 61$ #/IN

$q_{MAX} = 61 + 363$
$= 424$ LB/IN



TRUE VIEW SIDE PLATE

LIFT, SHEAR, AND MOMENT

THE LIFT DISRIBUTION OVER THE LENGTH OF THE BODY INCLUDING THE AFTERBODY IS SHOWN ON THE FOLLOWING PAGE. THE SHEAR AND MOMENT OBTAINED BY GRAPHICAL INTEGRATIONS OF THE LIFT AND SHEAR CURVES ARE ALSO INCLUDED ON THE FIGURE. A PROFILE SKETCH OF THE M-1L BODY COMPLETE IS SUPERPOSED TO SCALE ON THE LIFT CURVE FIGURE.

SHEAR AND BENDING MOMENTS

THE MAX. LIFT OCCURS FOR $\alpha = 30°$. THE PRESSURE DISTRIBUTION IS AVAILABLE FOR $\alpha = 28°$. THE LOAD, LIFT AND MOMENT CURVES FOR $\alpha = 28°$ ARE INCREASED BY A FACTOR DERIVED FROM THE ASSUMPTION THAT THE CHORDWISE LOAD DISTRIBUTION IS GEOMETRICALLY SIMILAR FOR THE TWO CONDITIONS.

THE NET INTEGRATED LIFT FOR $\alpha = 28°$ IS 8950 LB. FOR 1 RING.
THE NET LIFT FOR $\alpha = 30°$ IS 11800 LB. (REF FIG. 7)

THE SHEAR AND BENDING MOMENTS ARE INCREASED BY A FACTOR.

$$A = \frac{11800}{8950}$$
$$= 1.318$$

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CHECKED BY	TLH
DATE	
REVISED	

GOODYEAR AIRCRAFT

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SHEAR & BENDING MOMENTS

FORE BODY $\alpha = 30°$

SHEAR

STA	$V'_{(LIFT)}$ $(\alpha = 28)$	$1.318\, V'_{(LIFT)}$	R	$V_{(LIM)}$	$V_{(ULT)}$
10	150	198		198	297
20	430	567		567	851
28	[illegible]	857	-2250	857 -1393	1290 -2090
33	820	1082		-1168	-1750
45	1240	1689		-561	-842
60	2080	2740		+490	735
74	3080	4060		+1810	2715
83.74	4150 -4400	5470 -6330	-9550	+3220 -6330	4820 -9495
88	-4280	-5640		-5640	-8460
93.7	-3530	-4650		-4650	-6975

SECTION PROPERTIES

FORE BODY

THIN CIRCULAR SECTOR - HOLLOW.

$A = 2\alpha Rt$

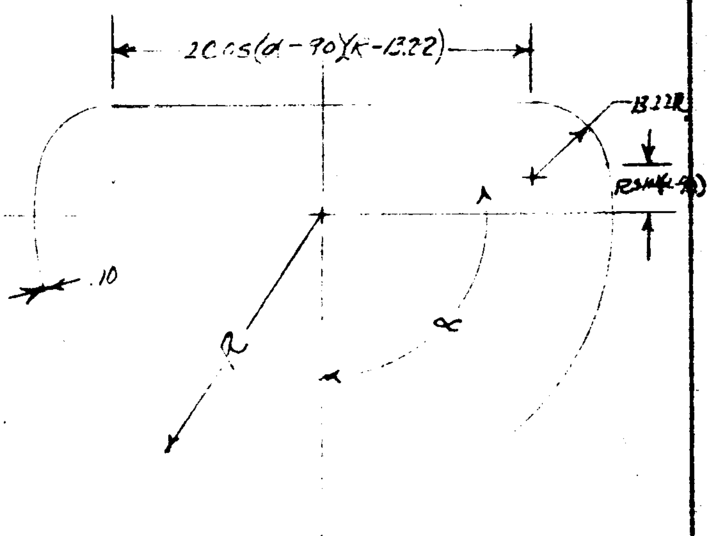
$y = R\frac{\sin\alpha}{\alpha}$

$I_{NA} = R^3 t\left[\alpha + \frac{1}{2}\sin 2\alpha - \frac{2\sin^2\alpha}{\alpha}\right]$

$R\sin(\alpha - 90) = 5.08 + .115(x-28)\Big|_{28}^{74}$

$R = 33.5 + .577(x-28)\Big|_{28}^{88}$

$w = 2\cos(\alpha - 90)(R - 13.22)$



TYPICAL SECTION
STA 28 - STA 74.

STA	x-28	.577(x-28)	R	.115(x-28)	R sin(α-90)	sin(α-90)	α-90	α	α (RAD)	sin α	cos(α-90)	R-13.22	w
28	0	0	33.5	0	5.08	.1514	8.71	98.71	1.724	.988	.988	20.28	39.76
33	5	2.31	36.31	.575	5.66	.1556	8.95	[illegible]	1.727	.988	.988	23.09	45.63
45	11	[illegible]	[illegible]	[illegible]	7.04	.1632	[illegible]	[illegible]	[illegible]	.987	.987	29.84	59.56
[illegible]	32	[illegible]	51.48	[illegible]	8.76	.1713	[illegible]	[illegible]	1.742	.985	.985	38.26	74.10
74	[illegible]	[illegible]	59.35	5.30	[illegible]	[illegible]	[illegible]	[illegible]	1.750	.985	.985	46.13	90.36
88	60	[illegible]	67.20	6.10	[illegible]	.1752	[illegible]	[illegible]	1.752	.984	.984	[illegible]*	[illegible]

*(R-12.07)

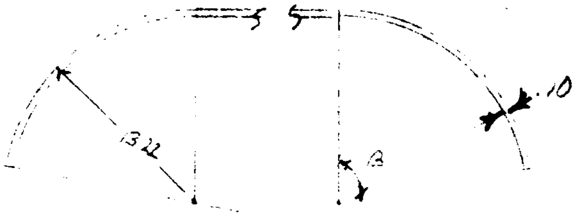
$t = .10$ IN

STA	R	α	sin α	A 2αRt	sin α/α	y	R^3t	[illegible]	2 sin²α/α	I_{NA}/R^3t	I_{NA}
28	33.5	1.724	.988	11.53	.573	19.2	3760	-.150	1.132	.442	1660
33	36.31	1.727	.988	12.54	.572	20.8	[illegible]	-.154	1.130	.443	2120
45	43.[illegible]	1.733	.987	14.12	.570	24.6	[illegible]	-.161	1.124	.446	35[illegible]
60	51.48	1.742	.985	[illegible]	.565	29.1	[illegible]	-.168	1.115	.459	6260
74	59.35	1.750	.985	20.75	.563	33.3	20[illegible]	-.173	1.110	.467	9760
88	67.20	1.752	.984	23.55	.561	37.7	30400	-.176	1.104	.472	14340

SECTION PROPERTIES

. FORE BODY

$\beta = 180 - \alpha$.



$I_{NA} = R^3 t \left[\beta + \frac{\sin 2\beta}{2} - \frac{2\sin^2\beta}{\beta} \right]$

STA	β	β_{RAD}	$\sin\beta$	$\frac{\sin\beta}{\beta}$	R	y	A	R^3t	$\frac{\sin 2\beta}{2}$	$\frac{2\sin^2\beta}{\beta}$	I_{NA}/R^3t	I_{NA}	
28	81.20	1.420	.988	.696	13.22	9.20	3.76	231.5	.1495	1.373	.1965	45.5	11.21
33	81.05	1.415	.988	.698	↑	9.23	3.76	↑	.1537	1.380	.1887	43.7	11.28
45	80.60	1.409	.987	.701		9.25	3.72		.1611	1.385	.1851	42.9	11.08
60	80.19	1.401	.985	.703	↓	9.28	3.71	↓	.1680	1.386	.1840	42.6	10.45
74	79.91	1.394	.985	.706	13.22	9.32	3.69	231.5	.1725	1.392	.1745	40.4	10.90
88	79.72	1.392	.984	.707	12.02	8.51	3.35	174.0	.1755	1.390	.1775	30.9	9.90

STA 28.

ITEM	A	y	Ay	Ay²	I_{CA}
FLAT	3.98	16.29	64.8	1052	—
13.22R	3.76	12.27	46.1	565	45.5
33.5R	11.53	−19.2	−222.0	4260	1660.0
TOTAL	19.27		−111.1	5877	1705.5

$\bar{y} = \frac{-111.1}{19.27}$

$\bar{y} = -5.77$ IN

$I_{NA} = 1706 + 5877 - 111.1 \times 5.77$
$= 7583 - 641$
$= 6942$ IN⁴.

$y_{top} = 16.29 + 5.77$
$= 22.06$ IN.

$y_{BOT} = -33.5 + 5.77$
$= -27.73$ IN.

SECTION PROPERTIES

FORE BODY

STA. 33.

ITEM	A	y	Ay	Ay^2	I_{OA}
FLAT	4.56	16.81	76.7	1289	—
13.22R	3.76	12.82	48.4	622	43.7
36.31R	12.54	-20.8	-261	5429	2120
Σ	20.86		-135.9	7340	2164

$$\bar{y} = \frac{-135.9}{20.86}$$
$$= -6.51 \text{ IN}$$

$$I_{NA} = 2164 + 7340 - 135.9(6.51)$$
$$= 9504 - 885$$
$$= 8619 \text{ IN}^4$$

$$y_{top} = 16.81 + 6.51$$
$$= 23.32 \text{ IN}$$

$$y_{BOT} = -36.31 + 6.51$$
$$= -29.80 \text{ IN}$$

SECTION PROPERTIES

FOREBODY

STA. 45

ITEM	A	y	Ay	Ay^2	I_{NA}
FLAT	5.86	18.12	106.4	1930	—
13.22R	3.72	14.15	52.6	745	43
43.06R	14.92	-24.6	-367	9030	3570
Σ	24.50		-208	11705	3613

$$\bar{y} = \frac{-208}{24.50} = \underline{-8.50 \ IN}$$

$$I_{NA} = 11705 + 3613 - 208(8.5)$$
$$= 15318 - 1770$$
$$= \underline{13548 \ IN^4}$$

$$y_{Top} = 18.12 + 8.50 = \underline{26.62 \ IN.}$$

$$y_{Bot} = -43.06 + 8.50 = \underline{-34.56 \ IN.}$$

SECTION PROPERTIES

FORE BODY

STA 60

ITEM	A	y	Ay	Ay^2	I_{oA}
FLAT	7.50	19.71	148	2920	—
13.22R	3.71	15.77	58.4	920	43
57.48R	17.90	-29.1	-521	15160	6260
Σ	29.11	—	-314.6	19000	6303

$$\bar{y} = \frac{-314.6}{29.11} = -10.81 \text{ IN}$$

$$I_{NA} = 19000 + 6303 - (314.6)(10.81) = 25303 - 3400 = 21903 \text{ IN}^4$$

$$y_{top} = 19.71 + 10.81 = 30.52 \text{ IN}$$

$$y_{BOT} = -57.48 + 10.81 = -46.67 \text{ IN}$$

SECTION PROPERTIES

FORE BODY

STA 74

ITEM	A	y	Ay	Ay^2	I_{oA}
FLAT	9.04	21.28	192	4090	—
13.22 R	3.69	17.38	64.1	1115	40
59.35 R	20.75	-33.3	-691	23000	9760
Σ	33.48		-434.9	28205	9800

$$\bar{y} = \frac{-434.9}{33.48}$$
$$= -13.00 \text{ IN}$$

$$I_{NA} = 9800 + 28205 - (434.9)(13)$$
$$= 38005 - 5655$$
$$= 32350 \text{ IN}^4$$

$$y_{top} = 21.28 + 13$$
$$= 34.28$$

$$y_{bot} = -59.35 + 13$$
$$= -46.35 \text{ IN.}$$

SECTION PROPERTIES

FORE BODY

STA. 88

ITEM	A	y	Ay	Ay^2	I_{NA}
FLAT	10.86	21.85	237	5178	—
12.02R	~~3.35~~	18.27	61.1	[illegible]	31
61.20R	23.55	-37.7	-888	33480	14340
Σ	37.76	—	-589.9	39776	14371

$$\bar{y} = \frac{-589.9}{37.76}$$

$$= -15.62 \text{ IN}$$

$$I_{NA} = 14371 + 39776 - 15.62(589.9)$$
$$= 54147 - 9217$$
$$= 44930 \text{ IN}^4$$

$$y_{top} = 21.85 + 15.62$$
$$= 37.47 \text{ IN}$$

$$y_{bot.} = -61.20 + 15.62$$
$$= -51.58 \text{ IN}$$

SECTION PROPERTIES

FORE BODY

$\alpha' = \arccos \frac{-\bar{y}}{R}$

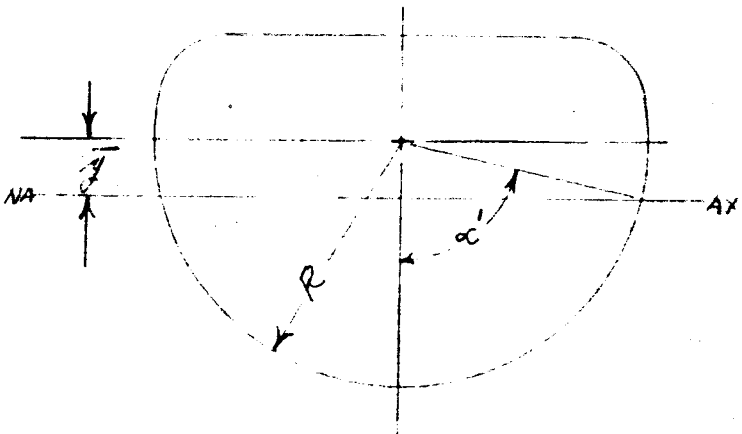
$A' = 2\alpha' R t$

$y' = R \frac{\sin \alpha'}{\alpha'}$

$q = \frac{VQ}{I_{NA}}$

$q/V = \frac{Q}{I_{NA}}$

$Q = A'(y' - \bar{y})$



$t = .10$ IN

TYPICAL SECTION

STA	R	$-\bar{y}$	$\cos\alpha'$	α'	$\sin\alpha'$	$\frac{\sin\alpha'}{\alpha'}$	A'	y'	$y'-\bar{y}$	Q	I_{NA}	q/V
25	33.50	5.77	.1722	1.398	.985	.705	9.37	23.62	17.85	167.3	6942	24.1
33	36.31	6.51	.1793	1.391	.984	.707	10.10	25.71	19.20	194	8619	22.5
45	43.06	8.50	.1972	1.374	.980	.712	11.83	30.65	22.15	262	13548	19.3
60	51.48	10.81	.2100	1.360	.978	.719	14.00	36.95	26.14	366	21903	16.8
74	60.35	13.20	.2190	1.350	.976	.723	16.02	42.91	24.91	479	32350	14.8
88	67.20	15.62	.2324	1.336	.973	.728	17.96	48.92	33.30	598	44930	13.4

ALLOWABLE LOADS

FORE BODY

THE FOREBODY SHEAR AND MOMENT CAPABILITIES ARE BASED ON THE CRITICAL STRESSES TO PRODUCE INITIAL SHEAR AND COMPRESSION BUCKLING OF THE LARGEST SHEAR AND COMPRESSION PANEL SIZES. USING THESE STRESSES TO CALCULATE LOADS GIVES THE SHEARS AND MOMENTS REQUIRED TO PRODUCE THE INITIAL SHEAR AND COMPRESSION BUCKLING OF PANELS. THESE ARE NOT THE ULTIMATE LOADS WHICH THE FOREBODY CAN CARRY. SINCE PANEL BUCKLING IS NOT DESIRABLE IN THE [illegible] THEY [illegible] BE USED AS [illegible] ALLOWABLE LOADS.

THE AIRLOAD MOMENT ON THE FOREBODY IS NOT KNOWN BECAUSE THE DRAG DISTRIBUTION OVER THE LENGTH OF THE FOREBODY [illegible] THE DRAG LOAD PRODUCES SIGNIFICANT MOMENTS IN THE MID BODY. THE TABLE PG. 38 SHOWS THE MOMENT-CAPABILITY OF THE FOREBODY TO BE SO MUCH [illegible] THE LIFT MOMENTS PG 26 THAT THE FORE BODY IS CONSIDERED SAFE BY [illegible]. TABLES PP 39 & 28 SHOWS THE MINIMUM [illegible] OF SAFETY [illegible] BUCKLING [illegible] HIGH.

ALLOWABLE LOADS

FOREBODY

COMPRESSION BUCKLING - FLAT TOP PANEL.
2024-T4 AL.AL.

THE PANELS ARE 26"X14" WITH THE LOAD ACTING ALONG THE 26" SIDE OF THE PANELS.

$\frac{a}{b} = \frac{14}{26}$
$= .54.$ $\qquad \sqrt{k_c} = 2.2$

$t = 0.10$ IN

$\frac{b}{t\sqrt{k_c}} = \frac{26}{0.1(2.2)}$
$= 118.$

$F_{c_{CR}} = 730$ PSI.

THIS CRITICAL STRESS IS CONSERVATIVELY ASSUMED TO BE THE ALLOWABLE STRESS AT ALL STATIONS ON FOREBODY

STA	y_{top}	I_{NA}	$\frac{I}{y}$	$(M \times 10^{-5})_{ALL}$
33	25.32	[illegible]	[illegible]	2.70 IN-K
45	[illegible]	[illegible]	509	3.71
60	30.52	[illegible]	718	5.24
74	34.26	32350	944	6.89
93	[illegible]	44920	[illegible]	.75

ALLOWABLE LOADS

FOREBODY

SHEAR BUCKLING - SIDE PANELS.

2024-T4 AL. AL

THE PANEL IS 36"X14" AND IS CONSERVATIVELY ASSUMED TO BE FLAT AND HAVE SIMPLE SUPPORTS

$a/b = \frac{36}{14} = 2.57.$

$\sqrt{k_s} = 2.36.$

$\frac{b}{t\sqrt{k_s}} = \frac{14}{0.1(2.36)} = 59.3$

$F_{SCR} = 3000$ PSI. (ASSUMED TO BE CRITICAL AT ALL STA.)

$V_{CR} = 2\frac{F_{SCR} I_{NA} t}{Q}$ $\qquad F_{SCR} t = 300$

STA	I_{NA}	Q	I_{NA}/Q	$\frac{1}{2} V_{CR}$ #	V_{CR} #
28	6942	167.3	41.5	12,450	24,900
33	8619	194	44.4	13,320	26,600
45	13548	262	51.7	15,510	31,000
60	21903	366	59.8	17,940	35,[illegible]
74	32350	479	67.5	20,250	40,500
88	44130	[illegible]	75.1	22,530	45,000

AFTERBODY ANALYSIS

THE AFTERBODY IS ANALYSISED BY MAKING ASSUMPTIONS WHICH APPEAR RATIONAL IN THE LIGHT OF THE CONSTRUCTION DETAILS INCORPERATED IN THE DESIGN. THE AIRLOAD ON THE TOP IS ASSUMED TO BE BEAMED IN A FORE AND AFT DIRECTION BY THE TOP 'AIRMAT.' THE LOADS OBTAINED AT THE LEADING EDGE, THE SUPPORTING CURTAIN, AND THE TRAILING EDGE BY THE BEAM ANALYSIS ARE MODIFIED BY ASSUMPTION TO CORRECT FOR THE EFFECTS OF THE FIN SUPPORTS AND THE AFTERBODY SHELL TRANSVERSE HOOP TENSION. THE AXIAL LOAD, SHEAR, AND BENDING MOMENT AT ANY AFTERBODY SECTION INDUCED BY BACK REACTION OF TOP SURFACE AIRLOAD, AIRLOADS ON THE BODY SHELL AND REAR BULKHEAD, AND THE INFLATION PRESSURES ARE ASSUMED TO BE REACTED BY A P/A, $\frac{VQ}{I}$, AND $\frac{MC}{I}$ STRESS DISTRIBUTIONS ON THE TOTAL SECTION AT THE STATION.

PRESSURE DISTRIBUTIONS OVER THE AFTERBODY DEVELOPED FROM DATA SUPPLIED BY NASA ARE SHOWN ON THE FOLLOWING PAGES. THE NET DRAG LOAD AND THE MOMENTS DUE TO THE DRAG LOADS ARE APPROXIMATED IN THE CALCULATIONS FOLLOWING THE PRESSURE DATA. THE TOTAL LIFT, DRAG, AND MOMENT FOR THE AFTERBODY ARE SHOWN ON Ps.

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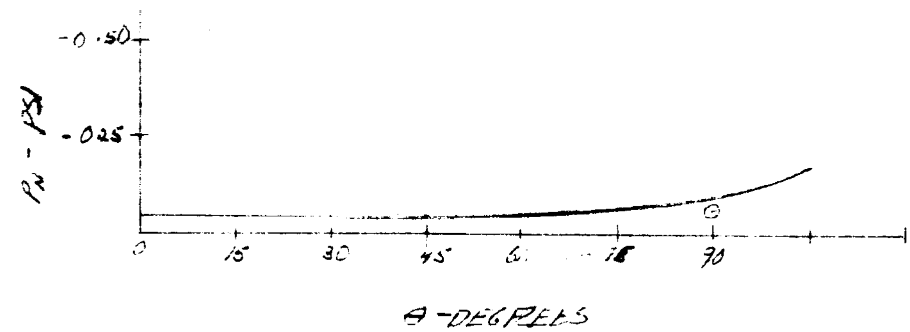
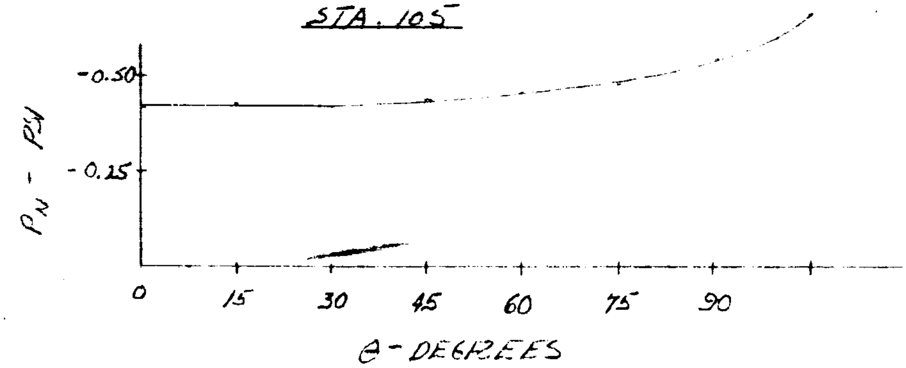
PRESSURE DISTRIBUTION $\alpha = 28.5^0$

AFTERBODY

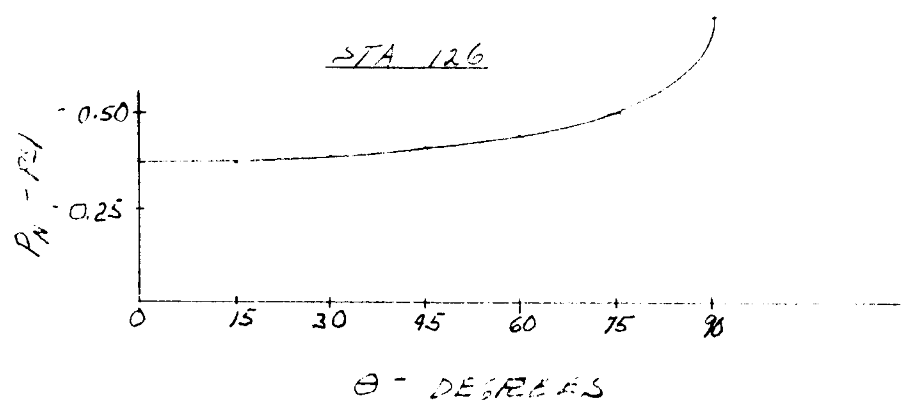
STA. 84.0



STA. 105



STA 126



ANGLE θ IS MEASURED FROM THE BOTTOM CENTERLINE.

PREPARED BY *apa*
CHECKED BY *TLH*
DATE
REVISED

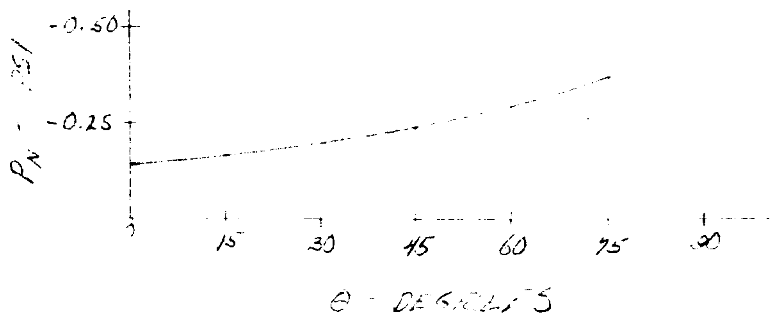
GOODYEAR AIRCRAFT

PAGE *B 42*
MODEL *M-1L*
GER- *11141 APP. B*
REF NO. *25500*

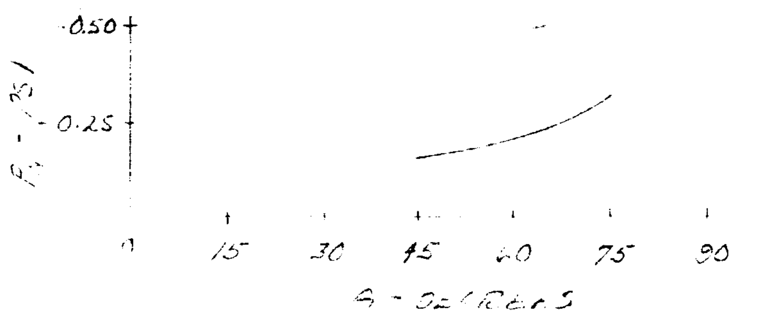
PRESSURE DISTRIBUTION $\alpha = 28.5^0$

AFTERBODY

STA 147



STA 158.5



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CHECKED BY TLH
DATE
REVISED

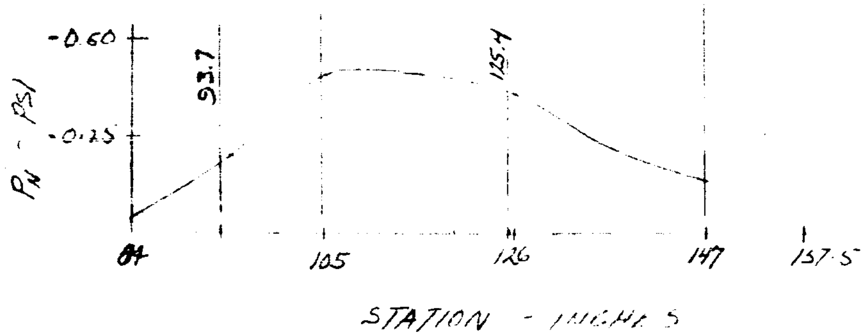
GOODYEAR AIRCRAFT

PAGE B 43
MODEL M-1L
GER- 11141 APR B
REF NO. 25500

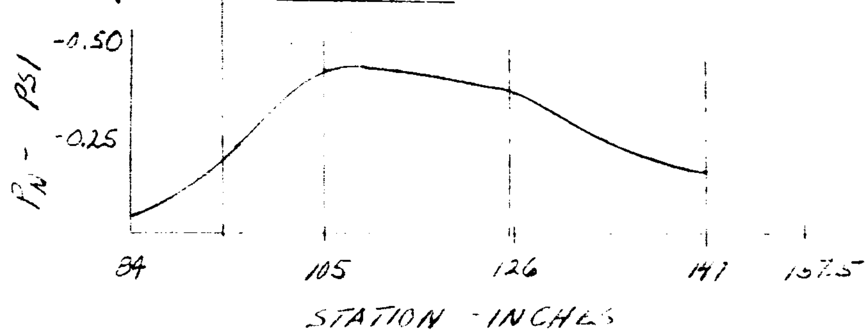
PRESSURE DISTRIBUTION $\alpha = 28.5^{\circ}$

AFTER BODY

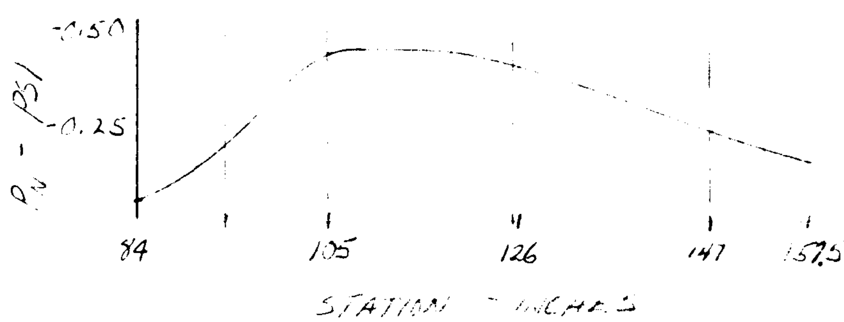
$\theta = 0^{\circ}$



$\theta = 15^{\circ}$



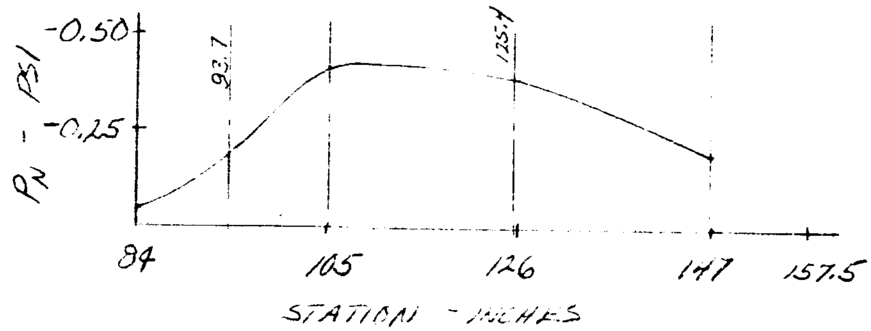
$\theta = 45^{\circ}$



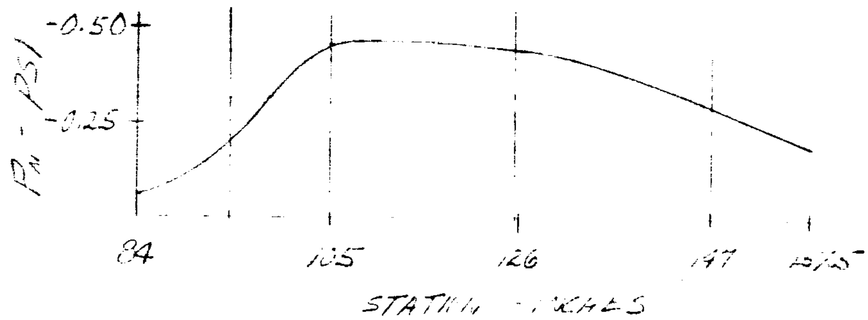
PRESSURE DISTRIBUTION - α = 25.5°

AFTERBODY

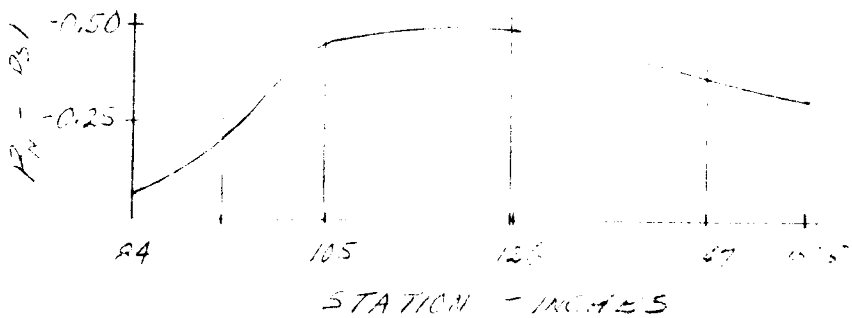
$\theta = 30°$



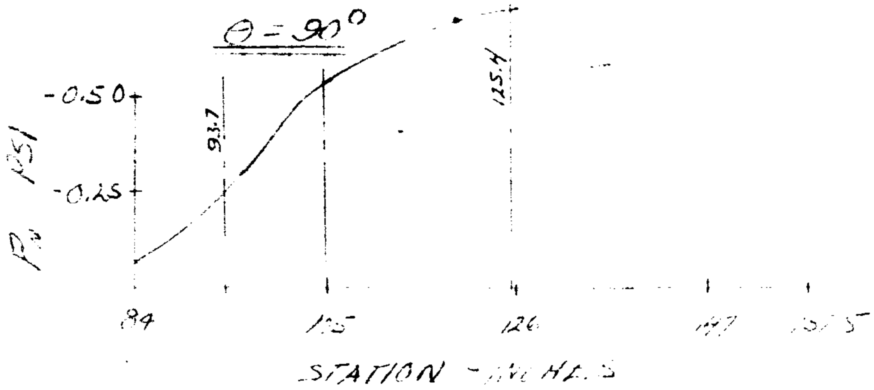
$\theta = 60°$

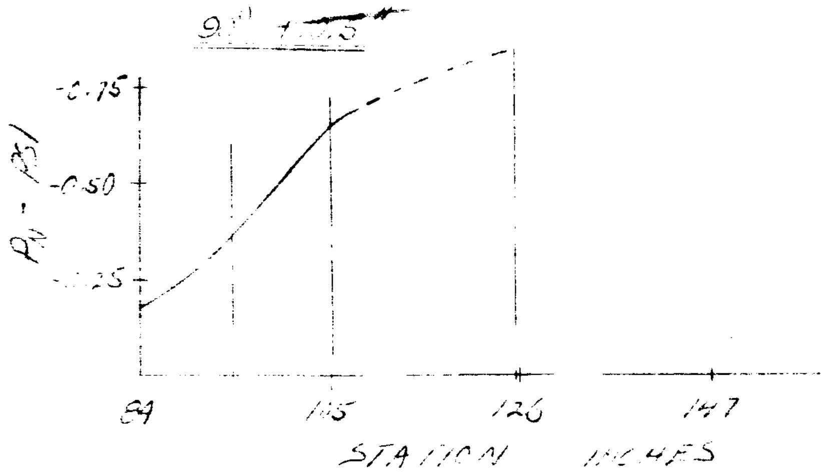


$\theta = 75°$



PRESSURE DISTRIBUTION - $\alpha = 28.5°$



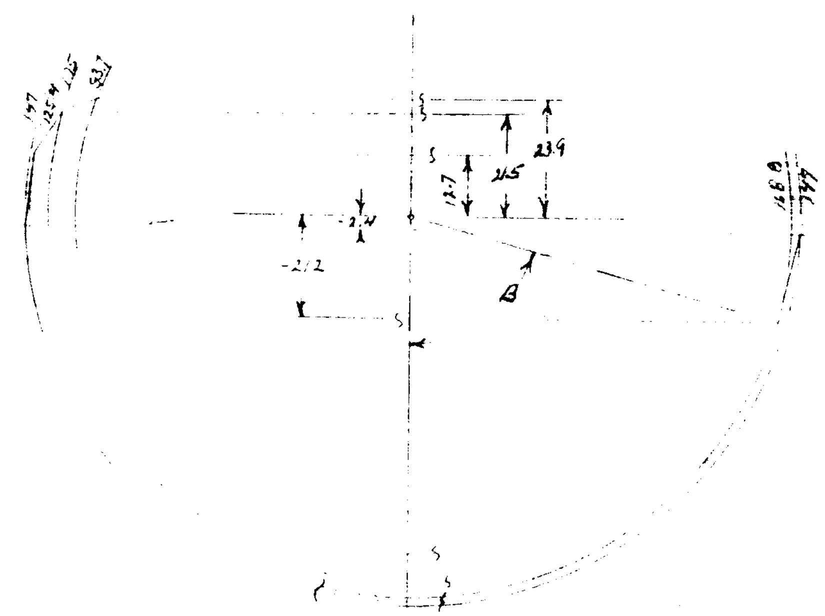


EXTERNAL LOADS $\alpha = 28.5$

AFTERBODY

SHELL

θ	93.7	105	125.4	147
0	-.180	-.405	-.365	-.136
15	-.187	-.415	-.372	-.160
30	-.190	-.410	-.387	-.190
45	-.195	-.428	-.402	-.235
60	-.195	-.450	-.437	-.291
75	-.205	-.455	-.490	-.370
90	-.245	-.530	-.720	
90+05	-.360	-.650	—	
AVG	-.219	-.467	-.453	-.230



$\frac{A}{Y} = 2 B R t$

$t = R_i - R_{i+1}$

EXTERNAL LOADS $\alpha = 28.5^\circ$

AFTERBODY

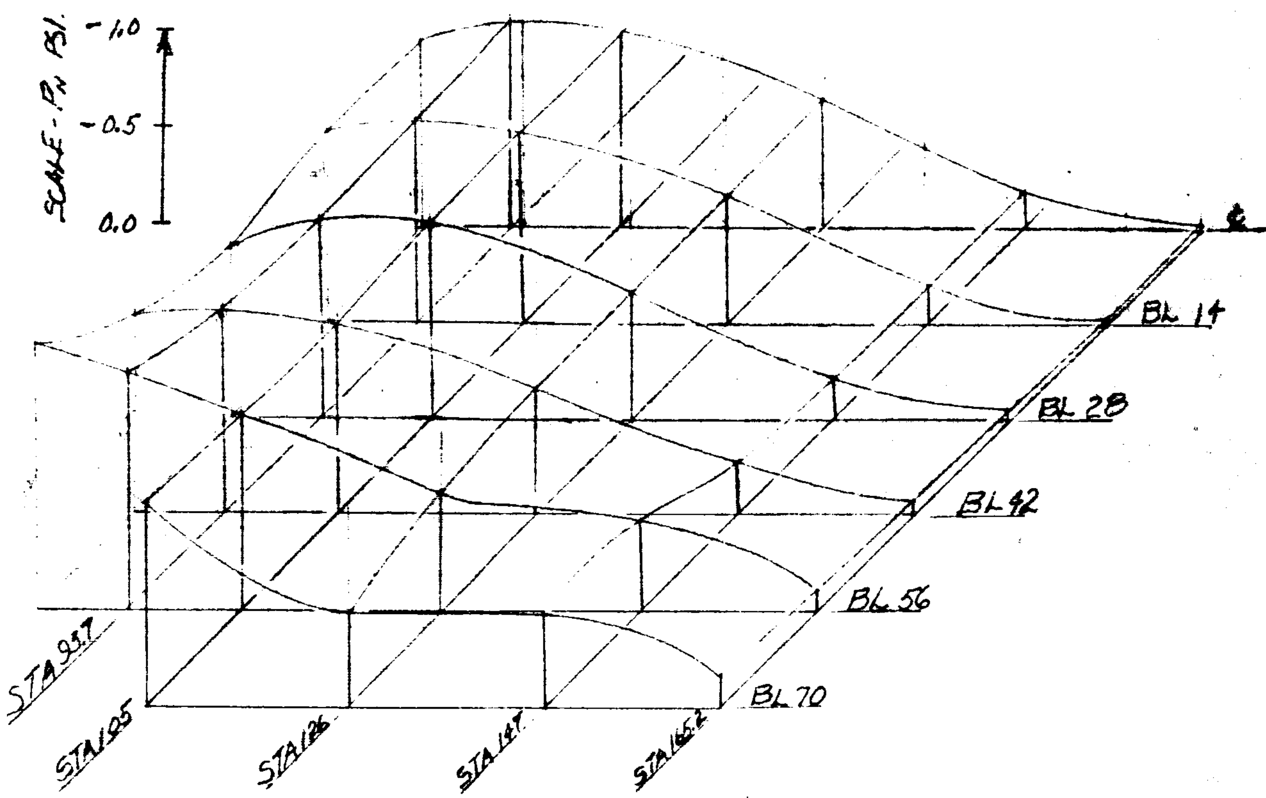
STA	R	Y	COS B	B°	SIN B	$B_{(RAD)}$	$\frac{SIN B}{B}$	t	A=2RBt	$\bar{Y}$	$A\bar{Y}$
13.9	67.6	23.9	-.343	110.1°	.939						
	(72.35)	(22.7)	-.314	108.3°	.949	1.890	.502	5.5	1504	36.3	54600
[illegible]	75.1	21.5	-.286	106.6°	.958						
	(77.35)	(17.1)	-.2211	102.8°	.975	1.794	.543	4.5	1249	42.0	52460
125.4	79.6	12.7	-.1595	99.2°	.987						
	(79.9)	(5.15)	-.0645	93.7°	.998	1.635	.610	.6	157	48.7	7650
147.0	80.20	-2.4	.0299	88.3°	.9996						
	(79.60)	(-11.8)	.1482	81.5°	.991	1.422	.695	-1.20	-272	55.3	-15640
168.6	79.0	-21.2	.2684	74.4°	.963						

STA	ΔA	$\Delta A\bar{Y}$	P_{AVG}	ΔP	P	ΔM	M
13.9			-.217		-1087		-42300
	1504	54600	(-.343)	-516		-18730	
[illegible]			-.461		-571		-23570
	1249	52460	(-.460)	-575		-34150	
125.4			-.453		4		580
	157	7650	(-.340)	-54		-2630	
147.0			-.230		57		3210
	-272	-15640	(-.215)	58		3210	
168.6			-.200		0		0

EXTERNAL LOADS $\alpha = 24.5^{\circ}$

AFTERBODY

TOP PRESSURE DISTRIBUTION



THE NORMAL LOAD PER INCH OF SURFACE IS CALCULATED AT STATIONS 93.7, 105, 126, 147, AND 165.2. THE PRESSURES AT OTHER ENDS OF THE CUTS ARE OBTAINED FROM TRENDS OF ABOVE FIGURE.

PREPARED a.p.a
CHECKED TLH
DATE
REV DATE

GOODYEAR
GOODYEAR AIRCRAFT CORPORATION
AKRON, OHIO

PAGE 849
MODEL M-1L
GER- 11141 APP. B
CODE IDENT 25500

EXTERNAL LOADS $\alpha = 28.5°$

AFTERBODY

TOP LOADS - AFT

STA 93.9

BL	ΔY	P_N	ΔW_N
℄		-1.056	
	14	(-1.048)	-14.68
14		-1.040	
	14	-(1.030)	-14.41
28		-1.020	
	14	(-1.035)	-14.50
42		-1.050	
	14	(-1.140)	-15.93
56		-1.230	
	14	(-1.345)	-18.82
70		-1.460*	
Σ	—	—	-78.34
2Σ	—	—	-156.68

STA. 105.0

BL	ΔY	P_N	ΔW_N
0		-1.01	
	14	(-.995)	-13.92
14		-.98	
	14	(-.995)	-13.92
28		-1.01	
	14	-(.995)	-13.92
42		-.98	
	14	(-.995)	-13.92
56		-1.00	
	14	(-1.03)	-14.41
70		-1.06	
	5.3	(-1.13)	-5.99
75.3		-1.20*	
Σ	—	—	-76.08
2Σ	—	—	-152.16

* ESTIMATED.

JR-218 (7-61)M
REF: ENGRG PROCEDURE S-017

EXTERNAL LOADS $\alpha = 28.5^0$

AFTERBODY

TOP LOADS - AFT

STA 126 (125.4)				STA 147			
BL	ΔY	P_N	ΔW_N	BL	ΔY	P_N	ΔW_N
0		-.66		0		-.19	
	14	(-.66)	-9.24		14	(-.19)	-2.66
14		-.66		14		-.19	
	14	(-.66)	-9.24		14	(-.205)	-2.87
28		-.66		28		-.22	
	14	(-.655)	-9.16		14	(-.24)	-3.36
42		-.65		42		-.26	
	14	(-.63)	-8.81		14	(-.37)	-5.18
56		-.61		56		-.48	
	14	(-.555)	-7.76		14	(-.48)	-6.71
70		-.50		70		-.48	
	9.7	(-.475)	-4.61		11.9	(-.465)	-5.54
79.7		-.45*		81.9		-.45*	
		Σ	-48.82			Σ	-26.32
		2Σ	-97.64			2Σ	-52.64

EXTERNAL LOADS $\alpha = 28.5^\circ$

AFTERBODY

TOP LOADS - AFT.

STA 168.8

BL	ΔY	p_N	$\Delta \omega_N$
0		-.030	
	14	(-.033)	-.46
14		-.035	
	14	(-.053)	-.74
28		-.070	
	14	(-.075)	-1.05
42		-.080	
	14	(-.092)	-1.29
56		-.101	
	14	(-.131)	-1.83
70		-.160	
	6	(-.173)	-1.04
76		-.185	

Σ -6.41
2Σ -12.82

STA.	z'	z	ω_N #/IN.	$\omega_N z$
13.7	0	23.9	-156.7	-3740
115	2.4	21.5	-152.2	-32[illegible]0
[illegible]	11.2	12.7	-97.6	-1240
[illegible] AXIS	23.9	0	—	—
147	26.4	-2.5	-52.6	+131
[illegible]	45.1	-21.2	-12.8	+260

PREPARED	a.P.a	PAGE	B 52
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DATE		GER-	11141 APP. B
REV DATE		CODE IDENT	25500

GOODYEAR
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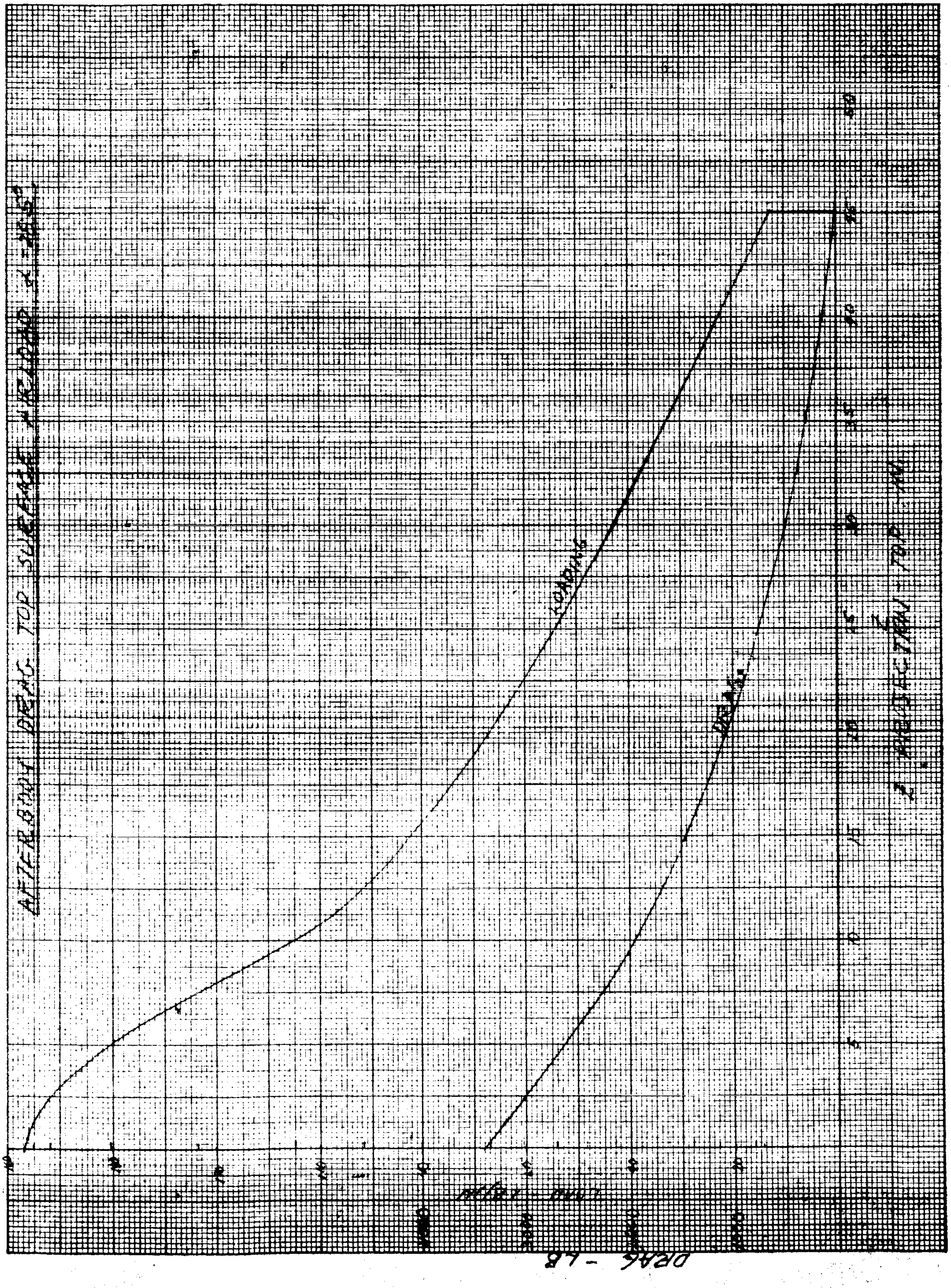
AKRON, OHIO



JR 220 (4-62)
REF: ENGRG PROCEDURE S-017

PREPARED O.P.A.
CHECKED TLH
DATE
REV DATE

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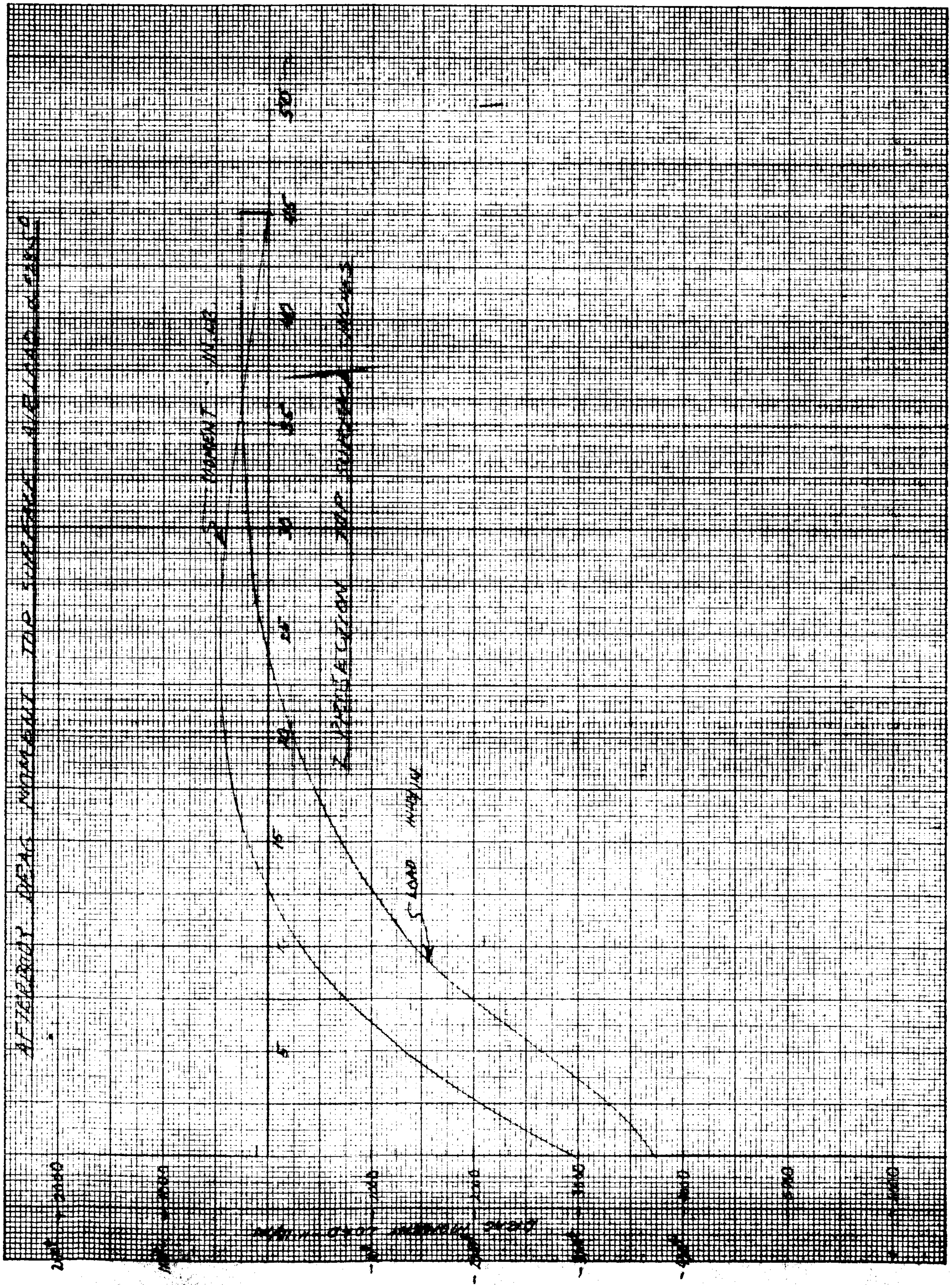
GOODYEAR AIRCRAFT CORPORATION
AKRON, OHIO

MODEL M-1L
GER- 11141 - APP. B.
CODE IDENT 25500



DRAG MOMENT - IN-LB

JR 220 (4-62)
REF: ENGRG PROCEDURE S-017

PREPARED BY A.P.A
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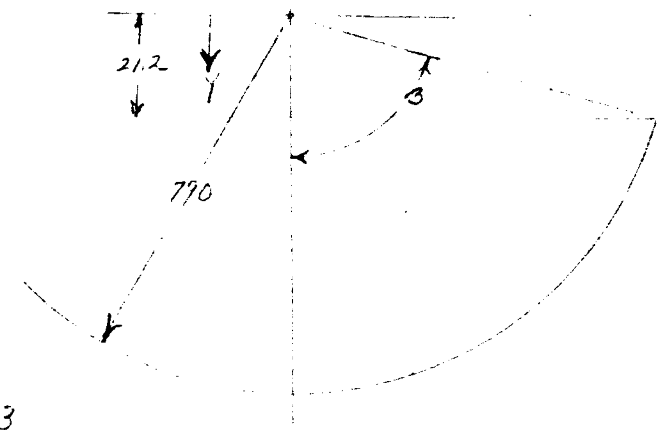
DATE
REVISED

GOODYEAR AIRCRAFT

MODEL M-1L
GER- 11141 APP. B.
REF NO. 25500

EXTERNAL LOADS $\alpha = 28.5^0$

AFTERBODY



BACK:

$A = R^2(\beta - .5\sin 2\beta)$

$y = 2R^3 \dfrac{\sin^3\beta}{3A}$

$\cos\beta = \dfrac{21.2}{79.0} = .268$ $\quad \sin\beta = .963$

$\beta = 74.4^0 = 1.30$ RAD.

$2\beta = 148.8$

$\sin 2\beta = .518$

$A = (79.0)^2(1.30 - .5 \times .518)$
$= 6240\ (1.041)$
$= 6500\ IN^2$

$Y = (6240)(2)(79)\dfrac{(.963)^3}{3(6500)}$
$= 45.2\ IN$

$AY = (45.2)(6500)$
$= 293\,800\ IN^3$

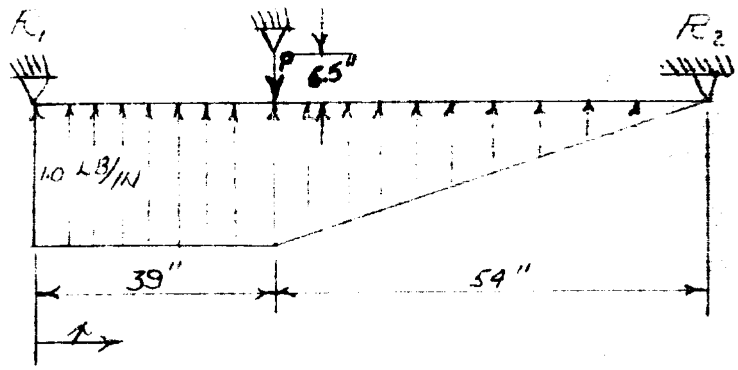
$P_{AVG} = .088$ PSI

[illegible]

$= 570$ LB.

$M = 293{,}800\ (.088)$
$= 25\,900$ IN. LB

THE TOP "AIRMAT" PANELS ARE ASSEMBLED IN A STRAIGHT LINE. PRIOR TO LOADING THE CATINARY WILL BE SLACK. WHEN THE JUNCTION OF THE "AIRMAT" AND CATINARY CURTAIN HAS DEFLECTED 6.5 INCHES THE CURTAIN WILL TAKE LOAD. A ONE INCH WIDE LONGITUDINAL STRIP OF THE TOP SURFACE IS ANALYZED AS SHOWN IN FIGURE BELOW.



$$93R_1 = \frac{54}{2}\left(\frac{2}{3}\right)54 + 39\left(54+\frac{39}{2}\right) - 54P.$$

$$R_1 = 41.25 - .581P.$$

$$93R_2 = \frac{39^2}{2} + \frac{54}{2}\left(\frac{54}{3}+39\right) - 39P$$

$$R_2 = 24.75 - .419P.$$

$$M = R_1 x - (1)\frac{x^2}{2}\Big|_0^{39}$$

$$= 41.25x - .581Px - \frac{x^2}{2}\Big|_0^{39.}$$

$$\frac{\partial M}{\partial P} = -.581x.$$

$$M = M_{39} + (R_1 - 39 + P)(x-39) - \frac{(x-39)^2}{2} + \frac{(x-39)^3}{324}\Big|_{39}^{93}$$

$$M = (21.75 - .581P)39 + (2.25 + .419P)(x-39) - \frac{(x-39)^2}{2} + \frac{(x-39)^3}{324}\Big|_{39}^{93.}$$

$$\frac{\partial M}{\partial P} = (.419x - 39)\Big|_{39}^{93}$$

$$V = R_1 - (1)x \Big|_0^{39}$$

$$= 41.25 - .581P - x \Big|_0^{39}$$

$$\frac{\partial V}{\partial P} = -.581 \Big|_0^{39}$$

$$V = R_1 - 39 + P - \left[(x-39) - \frac{(x-39)^2}{108}\right]\Big|_{39}^{93}$$

$$= 2.25 + .419P - \left[x - 39 - \frac{(x-39)^2}{108}\right]\Big|_{39}^{93}$$

$$\frac{\partial V}{\partial P} = .419 \Big|_{39}^{93}$$

$$U = \frac{1}{2EI}\int_0^l M^2\,dx + \frac{1}{2AG}\int_0^l V^2\,dx.$$

$$\delta_P = \frac{\partial U}{\partial P} = \frac{1}{EI}\int_0^l M\frac{\partial M}{\partial P}\,dx + \frac{1}{AG}\int_0^l V\frac{\partial V}{\partial P}\,dx.$$

$$\delta_P = \frac{1}{EI}\int_0^{39}\left(41.25x - .581Px - \frac{x^2}{2}\right)(-.581x)\,dx + \frac{1}{EI}\int_{39}^{93}\Big[(21.75 - .581P)39$$
$$+ (2.25 + .419P)(x-39) - \frac{(x-39)^2}{2} + \frac{(x-39)^3}{324}\Big](.419x - 39)\,dx$$
$$+ \frac{1}{AG}\int_0^{39}(41.25 - .581P - x)(-.581)\,dx + \frac{1}{AG}\int_{39}^{93}\Big\{2.25 + .419P$$
$$- \left[(x-39) - \frac{(x-39)^2}{108}\right]\Big\}.419\,dx.$$

$$\delta_P = \frac{-.581}{EI}\left[41.25\frac{x^3}{3} - .581P\frac{x^3}{3} - \frac{x^4}{8}\right]_0^{39} + \frac{1}{EI}\Big\{.419\Big[(21.75)(39)\frac{x^2}{2} - 22.65P\frac{x^2}{2} + (2.25 + .419P)\left(\frac{x^3}{3} - \frac{39x^2}{2}\right)$$
$$- \frac{x(x-39)^3}{6} + \frac{(x-39)^4}{24} + \frac{x(x-39)^4}{1296} - \frac{(x-39)^5}{6480}\Big] - 39\Big[21.75(39)x - 22.65Px + 2.25 + .419P\left(\frac{x^2}{2} - 39x\right)$$
$$- \frac{(x-39)^3}{6} + \frac{(x-39)^4}{1296}\Big]\Big\}\Big|_{39}^{93} - \frac{.581}{AG}\left[\left(41.25 - .581P - \frac{1}{2}x\right)x\right]_0^{39} + \frac{.419}{AG}\Big[(2.25 + .419P)x$$
$$- \frac{x^2}{2} + 39x + \frac{(x-39)^3}{324}\Big]\Big|_{39}^{93}.$$

$$\delta_p = \frac{-.581}{EI}\left[(41.25 - .581P)\frac{39^3}{3} - \frac{39^4}{8}\right] + \frac{1}{EI}\Big\{.419\Big[(21.75\times 39 - 22.65P)\frac{93^2-39^2}{2} + (2.25 + .419P)\times$$

$$\times\left(\frac{93^3-39^3}{3} - \frac{39(93^2-39^2)}{2}\right) - \frac{93(93-39)^2}{6} + \frac{(93-39)^4}{24} + \frac{93(93-39)^4}{1296} - \frac{(93-39)^5}{6480}\Big] - 39\Big[(21.75\times 39 - 22.65P)(93-39) +$$

$$+ (2.25 + .419P)\left(\frac{93^2-39^2}{2} - 39(93-39)\right) - \frac{(93-39)^3}{6} + \frac{(93-39)^4}{1296}\Big]\Big\} -$$

$$- \frac{.581}{AG}\left[(41.25 - .581P - 19.5)(39)\right] + \frac{.419}{AG}\Big[(2.25 + .419P)(93-39) -$$

$$- \frac{93^2}{2} + \frac{39^2}{2} + 39(93-39) + \frac{(93-39)^3}{324}\Big].$$

$$\delta_p = \frac{-.581}{EI}\left[(41.25 - .581P)(19.78)10^3 - 289\times10^3\right] + \frac{1}{EI}\Big\{.419\Big[(849 - 22.65P)\frac{8.65-1.52}{2}10^3 +$$

$$+ (2.25 + .419P)\left(\frac{804-59.3}{3} - \frac{39(8.65-1.52)}{2}\right)10^3 - 2440\times10^3 + 354\times10^3 + 2610\times10^3 - 71\times10^3\Big] - 39\Big[(849 - 22.65P)54 +$$

$$+ (2.25 + .419P)\left(\frac{8.65-1.52}{2}10^3 - 2.10\times10^3\right) - 26.2\times10^3 + 6.56\times10^3\Big]\Big\} -$$

$$- \frac{.581}{AG}\left[849 - 22.65P\right] + \frac{.419}{AG}\left[121.4 + 22.65P - 4320 + 760 + 2105 + 495\right]$$

$$\delta_p = \frac{-.581}{EI}\left[(529 - 11.49P)10^3\right] + \frac{1}{EI}\Big\{.419\Big[(3025 - 80.7P)10^3 + (246 + 45.8P)10^3 -$$

$$- 1547\times10^3\Big] - \left[(1788 - 47.7P)10^3 + (128.5 + 23.95P)10^3 - 766\times10^3\right]\Big\} -$$

$$- \frac{.581}{AG}\left[849 - 22.65P\right] + \frac{.419}{AG}\left[-843.6 + 22.65P\right]$$

$$\delta_p = \frac{10^3}{EI}\left[6.67P - 307 + 1268 - 33.8P + 103 + 19.19P - 647 - 1788 + 47.7P -\right.$$

$$\left. - 128.5 - 23.95P + 766\right] - \frac{1}{AG}\left[12.72P - 476 - 355 + 9.49P\right].$$

$$\delta_p = \frac{10^3}{EI}\left[+15.80P - 734\right] + \frac{1}{AG}\left[22.65P - 849\right]$$

$$E = 2170 \ \#/\text{in}$$

$$I = 2\left[1\times\left(\frac{6}{2}\right)^2\right] = 18 \text{ IN}^3.$$

$$EI = 18(2170) \cong 39000 \ \#\text{IN}^2$$

$G = p = 25.0$ PSI

$\bar{A} = 1 \times 6$
$= 6 \text{ IN}^2$

$AG = 6 \times 25$
$= 150$ lb.

$\delta_p = -6.5$ IN

$$-6.5 = \frac{10^3}{39000}\left[15.9\, P - 734\right] + \frac{1}{150}\left[22.65\, P - 849\right]$$

$$= .405\, P - 18.80 + .151\, P + 5.66$$

$$= +.556\, P - 24.46$$

$.556 P = 17.96$
$P = 32.2$

$R_1 = 41.25 - .581\,(32.2)$
$= 22.55$ LB.

$R_2 = 24.75 - .419\,(32.2)$
$= 11.25$ LB.

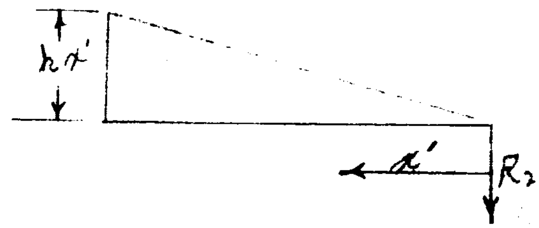
$\therefore x = 22.55$

$$M = (22.55)(22.55) - \frac{(22.55)^2}{2}$$

$= 254$ IN-LB.

FOR THE RIGHT HAND END OF BEAM THE MOMENTS ARE WRITTEN IN TERMS OF x' AS SHOWN BELOW.

$k = \frac{1}{54}$.



M IS MAX AT "x'" WHERE V IS "0.0".

$$V = R_2 - \frac{kx'^2}{2}.$$

$$M = R_2 x' - \frac{kx'^3}{6}.$$
$$= R_2 x' - \frac{x'^3}{324}.$$

$$x' = \sqrt{\frac{2R_2}{k}}$$

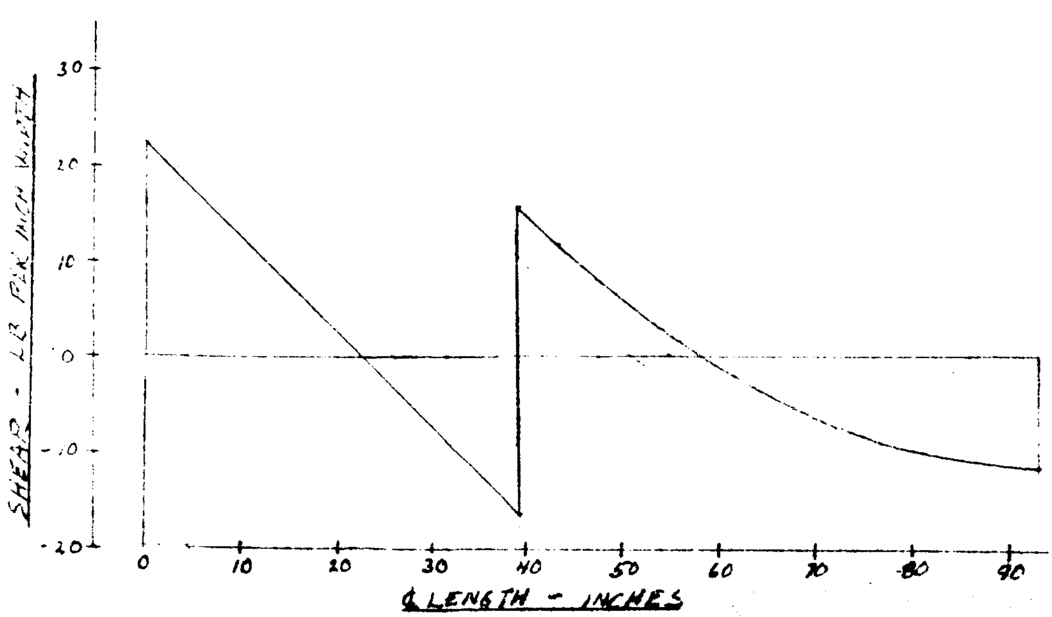
$$= \sqrt{108 \times 11.25}$$

$$x' = 34.9 \text{ IN.}$$

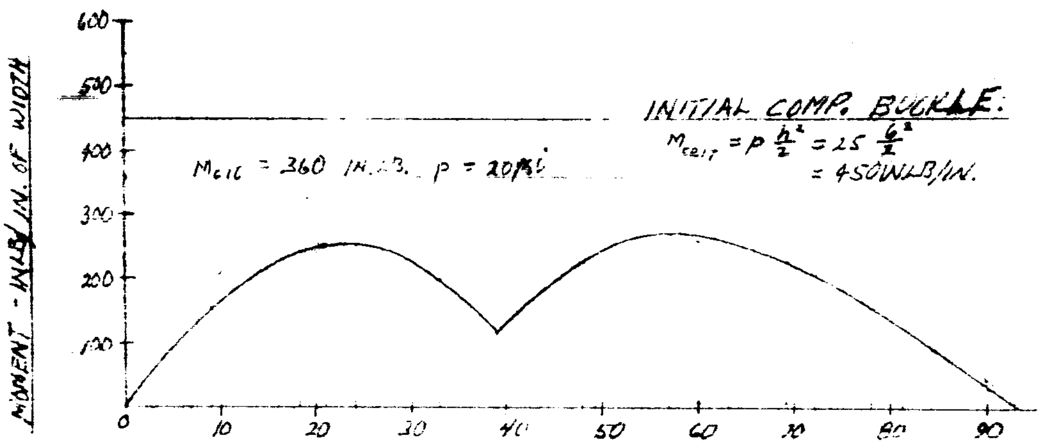
$$M_{MAX} = (11.25)(34.9) - \frac{(34.9)^3}{324}$$
$$= 393 - 131$$
$$= 262 \text{ IN.LB.}$$

THIS MOMENT IS CONSERVATIVE SINCE AFT BEAM SECTION IS PART OF A PLATE WITH 2:1 ASPECT RATIO.

SHEAR DIAGRAM.



MOMENT DIAGRAM



THE SHEAR DEFLECTIONS AT STATIONS ALONG THE ℄ LENGTH ARE CALCULATED USING THE EQUATION BELOW.

$$\Delta \delta_s = \frac{V_i + V_{i+1}}{2\,AG}\,\Delta x$$

USING $\Delta X = 3''$ AND $AG = 150$ LB

$$\delta_{s_m} = \sum_{i=0}^{i=m} .01(V_i + V_{i+1})$$

THE BENDING DEFLECTION AT STATIONS ALONG THE ℄ LENGTH ARE CALCULATED USING THE EQUATION SHOWN.

$$\delta_{b_n} = \frac{n}{31}\sum_{i=0}^{i=31} 3\left(\frac{A_i + A_{i+1}}{2}\right) - \sum_{i=0}^{i=n} 3\left(\frac{A_i + A_{i+1}}{2}\right)$$

$$A_m = \sum_{i=0}^{i=m} \frac{3.0}{EI}\left(\frac{M_i + M_{i+1}}{2}\right)$$

USING $EI = 39 \times 10^{3}$ IN.LB.

$$A_m = 10^{-3}\sum_{i=0}^{i=m} .0384\,(M_i + M_{i+1})$$

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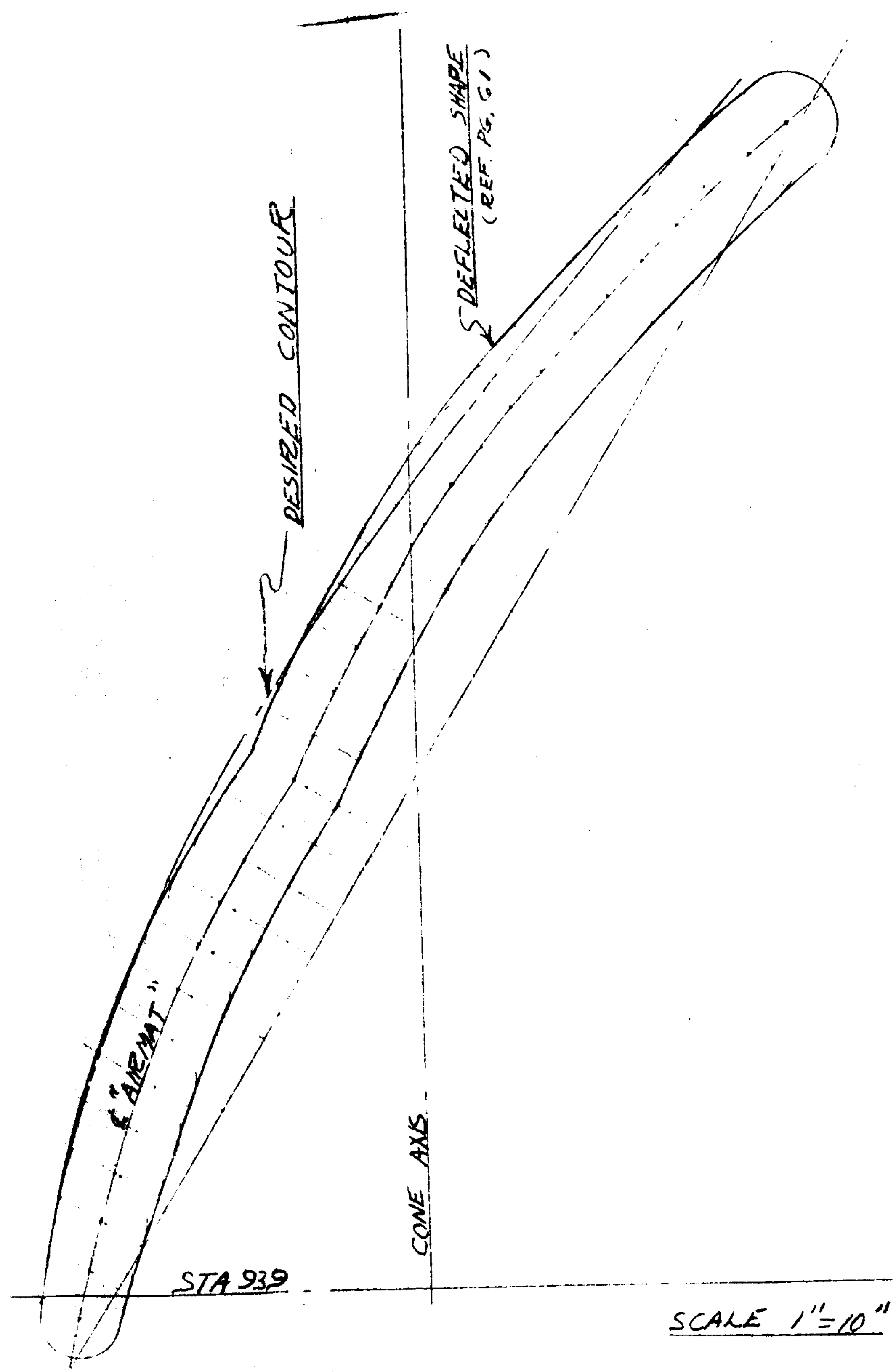
GOODYEAR
GOODYEAR AIRCRAFT CORPORATION
AKRON, OHIO

AIRMAT DEFLECTIONS

x	V	$.01(V_i+V_{i+1})$	δ_V	M	$.0[illegible](M_i+M_{i+1})$	$10A_i$	$1.5(A_i+A_{i+1})$	$\sum 1.5(A_i+A_{i+1})$	$\frac{III}{31}\sum_{i=0} 1.5(A_i+A_{i+1})$	δ_b	δ
0	22.55	.421	0	0	2.381	0	.0036	0	0	0	0
3	19.55	.361	.421	62	6.474	.024	.0176	.004	.677	.673	1.094
6	16.55	.301	.782	117	10.330	.093	.0434	.021	1.354	1.333	2.115
9	13.55	.241	1.043	152	13.478	.196	.0791	.068	2.031	1.966	3.049
12	10.55	.181	1.324	149	16.282	.331	.1236	.144	2.708	2.564	3.888
15	7.55	.121	1.505	225	18.010	.493	.1751	.267	3.385	3.118	4.623
18	4.55	.061	1.626	244	19.046	.674	.2307	.442	4.061	3.619	5.245
21	1.55	.001	1.687	252	19.392	.864	.2583	.674	4.739	4.064	5.751
24	-1.45	-.059	1.688	253	19.085	1.060	.3461	.962	5.415	4.453	6.141
27	-4.45	-.119	1.629	244	18.086	1.249	.4017	1.309	6.092	4.781	6.410
30	-7.45	-.179	1.510	227	16.358	1.429	.4533	1.710	6.769	5.059	6.569
33	-10.45	-.239	1.331	199	13.939	1.593	.4988	2.164	7.446	5.282	6.613
36	-13.45 ~~-6.45~~	-.299	1.092	164	10.906	1.732	.5360	2.662	8.123	5.461	6.553
39	+15.75	+.286	.793	120	10.906	1.841	.5658	3.198	8.800	5.602	6.395
42	12.80	+.229	1.079	164	13.101	1.951	.6062	3.767	9.477	5.710	6.789
45	10.05	+.170	1.308	198	16.243	2.090	.6513	4.373	10.154	5.881	7.189
48	7.53	+.126	1.484	225	18.010	2.252	.7026	5.025	10.830	5.805	7.289
51	5.07	+.078	1.610	244	19.200	2.432	.7547	5.727	11.507	5.780	7.390
54	2.75	+.035	1.688	256	19.853	2.624	.8171	6.486	12.184	5.698	7.386
57	.76	-.007	1.723	261	20.006	2.823	.8769	7.303	12.861	5.558	7.281
60	-1.47	-.043	1.716	260	19.734	3.023	.9365	8.185	13.538	5.358	7.074
63	-2.91	-.067	1.673	254	19.055	3.220	.9990	9.116	14.215	5.099	6.772
66	-3.99	-.099	1.604	243	18.048	3.411	1.0547	10.115	14.892	4.777	6.381
69	-5.92	-.131	1.505	227	16.666	3.571	1.1024	11.170	15.569	4.399	5.904
72	-7.17	-.154	1.374	207	15.053	3.755	1.1531	12.272	16.246	3.974	5.349
75	-8.25	-.174	1.220	185	13.171	3.907	1.1924	13.422	16.923	3.501	4.721
78	-9.17	-.191	1.046	158	11.059	4.040	1.2247	14.615	17.599	2.984	4.030
81	-9.92	-.204	.855	130	8.714	4.161	1.2585	15.843	18.276	2.433	3.288
84	-10.50	-.214	.651	99	6.377	4.239	1.2813	17.102	18.953	1.851	2.502
87	-10.12	-.221	.437	67	3.814	4.303	1.2960	18.383	19.630	1.247	1.684
90	-11.17	-.224	.216	34	1.306	4.341	1.3043	19.680	20.307	.627	.843
93	-11.25		-.008	0		4.357		20.984	20.984	0	0

JR-218 (7-61)M •
REF: ENGRG PROCEDURE S-017

TOP SURFACE CONTOUR



CURTAIN LOAD.

THE LOAD PER INCH ON THE CURTAIN WILL BE AS CALCULATED ON PAGE 58 NEAR THE CENTER OF THE VEHICLE. THE FIN STRUCTURE WILL ABSORB SOME OF THE LOAD IN ITS AREA. THE LOAD AT B.L 50, THE FIN ℄, IS ESTIMATED TO BE 20 LB/IN. THIS IS ALL OF THE SHEAR FROM THE "AIRMAT" FORWARD OF THE CURTAIN AND A LITTLE FROM THE AFT SIDE. THE CURTAIN LOAD IS ASSUMED TO DECREASE LINEARLY FROM 32.2 LB/IN AT BL 25 TO 20 LB/IN AT BL 50. THE LOAD IS ASSUMED TO BE A CONSTANT 17 LB/IN FROM B.L. 50 TO B.L. 65.5. THE LOAD THEN DECREASES LINEARLY TO 6 LB/IN AT THE OUTER EDGE. THE LAST DECREASE REFLECTS THE INFLUENCE OF THE TRANSVERSE HOOP TENSIONS. THE DESCRIBED LOAD IS PICTURED ON PAGE 64 AS ARE THE CATENARY CURVES DEVELOPED BY A TRIAL AND ERROR GRAPHICAL METHOD. THE RESULTING CABLE TENSIONS ARE INCLUDED IN THE FIGURE ON PAGE 64, ALSO.

THE CURTAIN IS OVERSTRENGTH FOR THE AIRLOADS WHICH ARE USED TO CHECK IT. THE CURTAIN IS DESIGNED IN THIS MANNER, ANTICIPATING OPENING LOADS WHICH ~~MAY~~ EXCEED THE AERODYNAMIC LOADS FROM THE STRUCTURE. NO WAY IS KNOWN AT PRESENT TO DEFINE THESE DEPLOYMENT LOADS. ONCE THESE HAVE BEEN MEASURED IT IS A DISTINCT POSSIBILITY THAT A LIGHTER CURTAIN MAY BE MORE ACCURATELY DESIGNED.

CATENARY CURTAIN.

(REF DWG. 62QS985.

THE CABLES ALONG THE CATENARY CURVES ARE 5/32" CARBON STEEL. THE END FITTINGS ARE OF THE SWAGED TYPE WHICH ARE 100% EFFICIENT. (REF MIL-HNDBK-5 PG. 8.2.3.1)

THE BREAKING STRENGTH OF 5/32" MIL-W-1511 CABLE IS 2800 LB. (REF MIL-HNDBK-5 PG. 8.2.1.2)

THE MAX LOAD IN THESE CABLES IS

$P = (1.5)(670) = 1005\ LB$ (REF. PG. 64)

$M.S. = \frac{2800}{1005} - 1 = HIGH.$

AN AN24-12A BOLT IN DOUBLE SHEAR ATTACHES THE CABLE TO -11 LINK

$P = 2(3680)$ (REF MIL-HNDBK-5 PG 8.1.1.1.1(a))
$= 7360\ LB.$ M.S = HIGH.

THE TOTAL LOAD @ b IS 980 LB (LIMIT)

$P_{ult} = 1.5(980)$
$= 1470\ LB.$

THIS LOAD IS CARRIED BY A 5/16 AN BOLT IN DOUBLE SHEAR.

$P_{all} = 2(5750)$ (REF MIL HNDBK-5 PG 8.1.1.1.1(a))
$= 11500\ LB$

M.S = HIGH.

JR-218 (7-61)M
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GOODYEAR AIRCRAFT

SECTION PROPERTIES

FABRIC [illegible]

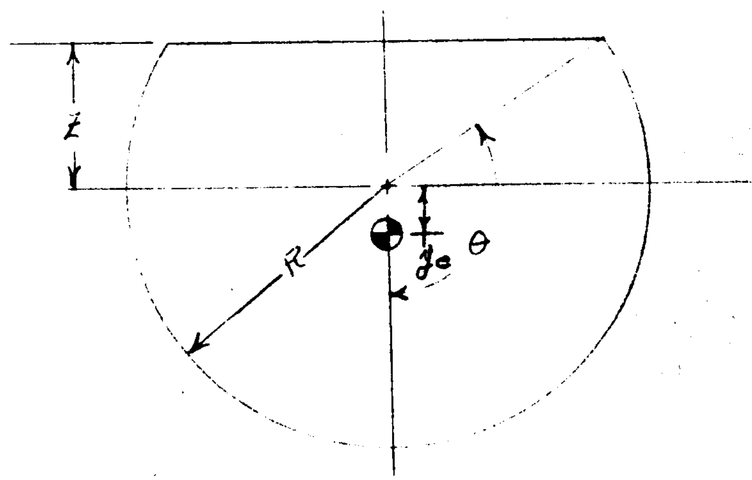
ENCLOSED AREA

ASSUME ALL SECTIONS ARE SIMILAR TO FIGURE SHOWN.

$$A_e = R^2(\theta - .5\,SIN\,2\theta)$$

$$y_e = 2R^3\,\frac{SIN^3\theta}{3A}$$

$$= \frac{2}{3}R\,\frac{SIN^3\theta}{\theta - .5\,SIN\,2\theta}$$



STA	R	Z	COSθ	θ°	θ RAD.	2θ	SIN2θ	SINθ	$SIN^3\theta$	-.5SIN2θ	θ-.5SIN2θ
93.9	69.6	23.9	-.343	110° 4'	1.925	220° 8'	-.645	.940	.830	.323	2.248
105	75.1	21.5	-.286	106° 37'	1.862	213° 14'	-.548	.958	.879	.274	2.136
125.4	79.6	12.7	-.1594	99° 10'	1.733	198° 20'	-.315	.987	.961	.158	1.891
147.0	80.6	-2.4	.02975	88° 18'	1.542	176° 36'	.0593	.9996	.999	-.030	1.512
152.5	79.8	-7.3	.0916	84° 45'	1.450	169° 30'	.182	.996	.988	-.091	1.389

STA	R	R^2	θ-.5SIN2θ	A (IN²)	$\frac{2}{3}R$	$SIN^3\theta$	$\frac{SIN^3\theta}{\theta - .5SIN2\theta}$	y_e
93.9	69.6	4850	2.248	10900	46.5	.830	.369	17.14
105	75.1	[illegible]	2.136	12000	50.1	.879	.411	20.59
125.4	79.6	6320	1.891	11950	53.1	.961	.508	27.00
147.0	80.6	6490	1.512	9820	53.8	.994	.610	35.45
152.5	79.8	6350	1.389	8820	53.2	.988	.712	37.90

SECTION PROPERTIES

FABRIC AFTERBODY

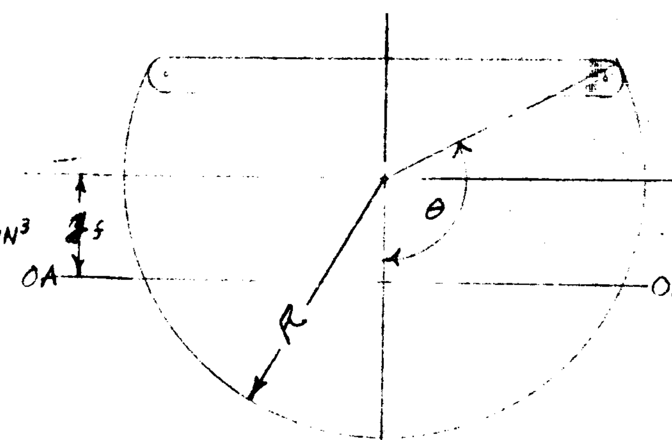
THIN CIRCULAR SECTOR - HOLLOW

FOR FABRIC "t", MAT'L THICKNESS, IS UNITY.

$A_s = 2\theta R$ IN.

$y_s = R\,\frac{\sin\theta}{\theta}$

$I_{OA} = R^3\left[\theta + .5\sin 2\theta - \frac{2\sin^2\theta}{\theta}\right]$ IN^3



TYPICAL SECTION

STA	R	$10^{-3}R^3$	θ	A_s	$\sin\theta$	y_s	$.5\sin 2\theta$	$2\sin^2\theta$	$-\frac{2\sin^2\theta}{\theta}$	$\frac{I_{OA}}{R^3}$	I_{OA}	$R\sin\theta$
93.9	69.6	338	1.925	268	.940	34.0	-.323	1.767	-.917	.685	231×10^3	65.5
105	75.1	424	1.862	282	.958	38.6	-.274	1.834	-.984	.604	256×10^3	72.0
125.4	79.6	505	1.733	276	.987	45.4	-.158	1.950	-1.123	.452	228×10^3	78.6
147	80.6	524	1.542	249	.9996	52.2	.030	1.999	-1.295	.277	145×10^3	80.6
152.5	79.9	508	1.480	236	.996	53.7	.091	1.984	-1.341	.230	117×10^3	79.4

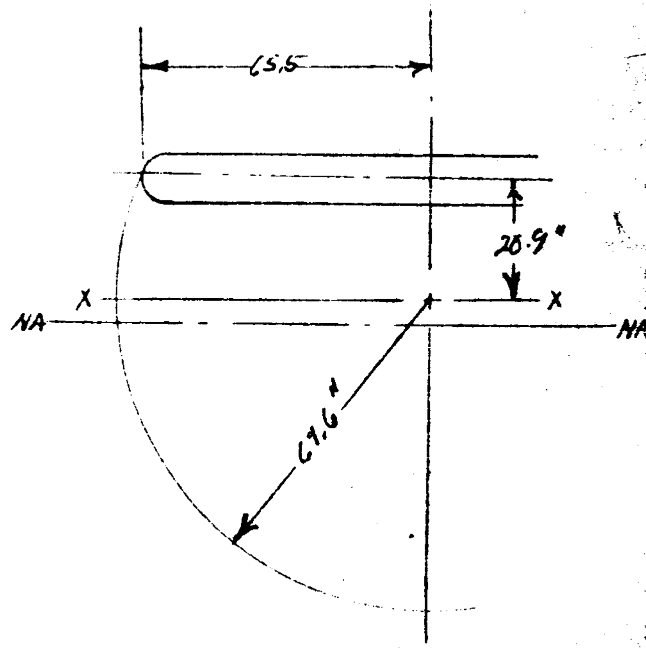
THE AIRMAT FACES ARE ASSUMED TO BE TWICE AS STIFF AS THE BODY SHELL FABRIC.

SECTION PROPERTIES

FABRIC AFTERBODY

STA. 93.9

AIRMAT.



$A = (2)(2)(2)(65.5)$ (REF PG 5)
$= 524.0$ IN.

$I_{OA} = (2)(2)(2)(65.5)\left(\frac{6}{2}\right)^2$
$= 4710\ IN^3$

$y = (23.9) - 3$
$= 20.9$

ITEM	A	y	A y	A y²	I_{OA}
AIRMAT	524	20.9	10940	229000	4710
SHELL	268	-34.0	-9110	310000	231000
Σ	792		1830	539000	235710

$\bar{y} = \frac{1830}{792}$
$= 2.31$ IN

$I_{NA} = 539000 + 235710 - 2.31(1830)$
$= 774700 - 4400$
$= 770300\ IN^3$

$y_{top} = 23.9 - 2.31$
$= 21.59$ IN

$y_{bot} = -69.6 - 2.31$
$= -71.91$ IN

SECTION PROPERTIES

FABRIC AFTERBODY

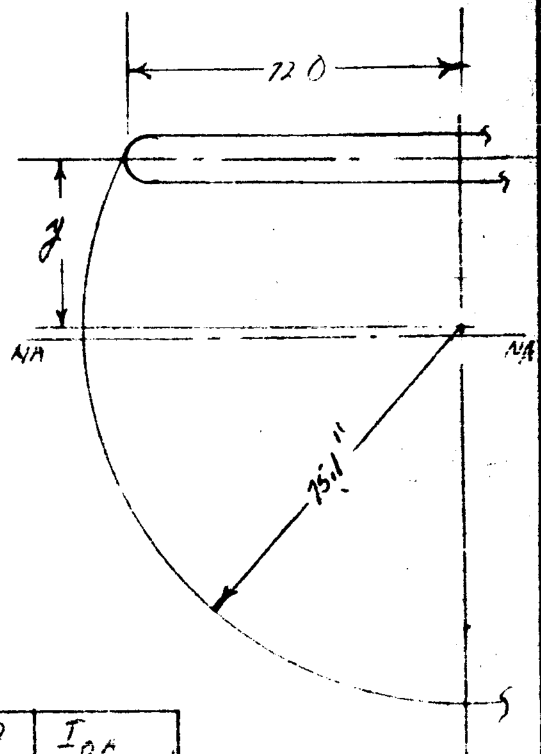
STA. 105

AIRMAT.

$A = (2)(2)(2)(72.0)$ (REF PG. 15)
$A = 576$ IN.

$I_{OA} = (2)(2)(2)(72)(\frac{6}{2})^2$
$= 5190$ IN^3

$y = 21.5 - 3.0$
$= 18.5$ IN



ITEM	A	y	Ay	Ay^2	I_{OA}
AIRMAT	576	18.5	10680	197500	5190
SHELL	282	-38.6	-10890	421000	256000
Σ	858		-210	618500	261190

$y = \frac{-210}{858}$
$= -.25$ IN

$I_{NA} = 261200 + 618500 - .25(210)$
$= 879700 - 52$
$= 879600$ IN^3

$y_{top} = 21.5 - (-.25)$
$= 21.75$ IN

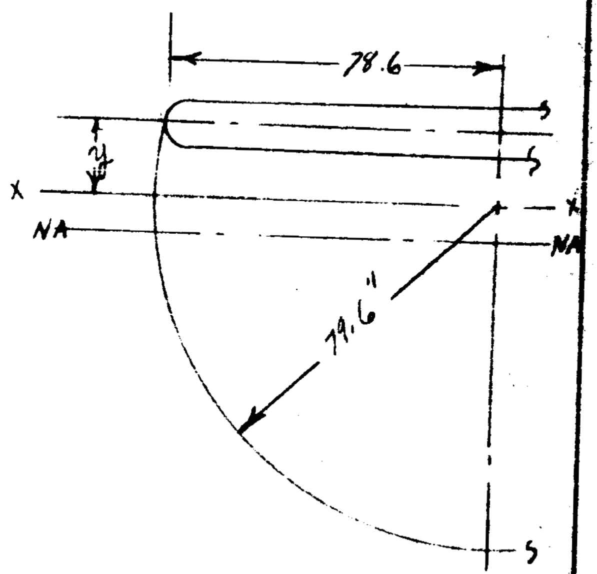
$y_{bot} = -75.1 - (-.25)$
$= -74.85$ IN

SECTION PROPERTIES

FABRIC AFTERBODY

STA 125.4

AIRMAT



$A = (2)(2)(2)\,78.6$ (REF. PG. 1)
$= 629$ IN

$I = (2)(2)(2)(78.6)\left(\frac{6}{2}\right)^2$
$= 5660$ IN^3

$y = 12.7 - 3$
$= 9.7$ IN

ITEM	A	y	Ay	Ay²	I_{OA}
AIRMAT	629	9.7	6100	59100	5660
SHELL	276	-45.4	-12510	567000	228000
Σ	905		-6410	626100	233700

$\bar{y} = \frac{-6410}{905}$
$= -7.05$

$I_{NA} = 626100 + 233700 - (7.05)(6410)$
$= 859800 - 45200$
$= 814600$ IN^3

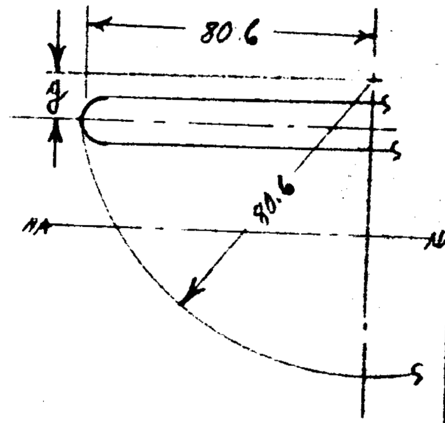
$y_{top} = 12.7 + 7.05$
$= 19.75$ IN

$y_{bot} = -79.6 + 7.05$
$= -72.55$ IN

SECTION PROPERTIES

FABRIC AFTERBODY

STA 147.



AIRMAT

$A = (2)(2)(2)(80.6)$ (REF PG 95)
$= \underline{645 \text{ IN}}$

$I_{oA} = (2)(2)(2)(80.6)\left(\frac{6}{2}\right)^2$
$= \underline{5800 \text{ IN}^3}$

$y = -2.4 - 3$
$= \underline{-5.4 \text{ IN.}}$

ITEM	A	y	Ay	Ay²	I_{oA}
AIRMAT	645	-5.4	-3480	18800	5800
SHELL	249	-52.2	-13000	679000	145000
Σ	894		-16480	697800	150800

$\bar{y} = \frac{-16480}{894}$
$= \underline{-18.45}$

$I_{NA} = 697800 + 150800 - (18.45)(16480)$
$= 848600 - 304000$
$= \underline{544600 \text{ IN}^3}$

$y_{top} = -2.4 - (-18.45)$
$= \underline{16.05 \text{ IN}}$

$y_{bot} = -80.6 - (-18.45)$
$= \underline{-62.15 \text{ IN}}$

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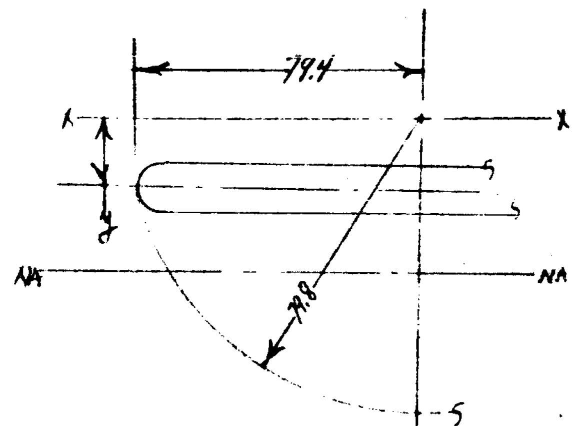
GOODYEAR AIRCRAFT

SECTION PROPERTIES

FABRIC AFTERBODY

STA 152.5

AIRMAT



$A = (2)(2)(2)(79.4)$
$= 635 \, IN$

$I_{0A} = (2)(2)(2)(79.4)\left(\frac{6}{2}\right)^2$
$= 5710 \, IN^3$.

$y = -7.3 - 3$
$= -10.3 \, IN$

ITEM	A	y	Ay	Ay²	I_{0A}
AIRMAT	635	-10.3	-6540	67400	5710
SHELL	236	-53.7	-12680	681000	117000
Σ	871		-19220	748400	122700

$y = \frac{-19220}{871}$
$= -22.05 \, IN$

$I_{NA} = 748400 + 122700 - (22.05)(19220)$
$= 871100 - 424000$
$= 447100 \, IN^3$

$y_{top} = -7.3 - (-22.05)$
$= 14.75 \, IN$

$y_{bot} = -79.8 - (-22.05)$
$= -57.75 \, IN.$

AFT BODY SHELL
MEMBRANE LOADS.

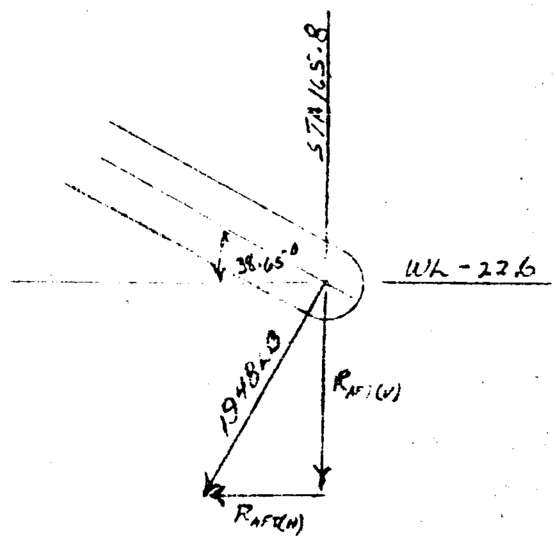
AS FABRICATED AND WITH NO LOAD THE TOP SURFACE WILL BE WELL BELOW CONTOUR. THE BODY FABRIC WILL BE SLACK IN THE TRANSVERSE DIRECTION. WHEN LOADS ARE APPLIED THE BODY ASSUMES THE CORRECT SHAPE BUT THE LONGITUDINAL DIRECTION WILL LOAD FIRST BECAUSE ONLY SMALL DEFLECTONS ARE REQUIRED TO PRODUCE LOADS. THEREFORE THE ASSUMPTION IS MADE THAT THE LONGITUDINAL STRESS DOMINATES EVEN THOUGH THE LONGITUDINAL RADII ARE SOMEWHAT LARGER. THE PRESSURE REQUIRED TO PROVIDE THE PROPER RELATION BETWEEN RADIUS AND TENSION IS SUBTRACTED FROM THE AVERAGE PRESSURES ON THE MEMBRANE AT THE VARIOUS SECTIONS. THE REMAINING PRESSURE IS CARRIED BY TENSION IN THE TRANSVERSE DIRECTION. THIS TENSION REDUCES THE LOADS TRANSFERED FORE AND AFT BY THE TOP SURFACE. THE AFT REACTION ENTERS THE LONGITUDINAL FABRIC TENSION CALCULATION. 75% OF THE TOTAL AFT REACTION IS ASSUMED TO BE EFFECTIVE IN THE LONGITUDINAL FABRIC TENSION CALCULATIONS. THE LONGITUDINAL RADIUS IS VARIABLE BUT DOES NOT DIFFER GREATLY FROM 90 INCHES.

AFT BODY SHELL
MEMBRANE TENSION

$R_{AFT} = (.75)(11.25)(79)(2)\sin 74.4^\circ$ (REF PP. 58C12)
$= \underline{1284\ LB.}$

$R_{AFT(V)} = 1284(\cos 38.65^\circ)$
$= \underline{1003\ LB.}$

$R_{AFT(H)} = 1284(\sin 38.65^\circ)$
$= \underline{802\ LB}$



STA. 93.9.

$\bar{y} = 2.31$ (REF PG. 67)

$M_a = 1003(165.8 - 93.9) + 802(22.6 + 2.31) - 42{,}300 + 25{,}900$
$+ 2.31(-1087 + 570)$
$= 72{,}100 + 20{,}000 - 42{,}300 + 25{,}900 - 1{,}200$
$= 76{,}900$ IN. LB.

$P_A = 802 + (10{,}900)(.2) + (25)(6)(2)(65.5) - 1{,}087 + 570$
$= 802 + 2180 + 19{,}650 - 1{,}087 + 570$
$= 22{,}115$ LB.

MOM. - PRES.

$M_p = -(2)(6)(65.5)(25)(21.59 - 3) + (.20)(10900)(17.14 + 2.31)$
$= -365{,}300 + 42{,}400$
$= -322{,}900$ IN. LB.

$M = -322{,}900 + 76{,}900$
$= -246{,}000$ IN. LB.

AFT BODY SHELL
MEMBRANE TENSION

STA 93.9 (CONT)

$$T = \frac{22,115}{792} + \frac{-246,000}{770,300}(-y)$$

$$= 27.9 + .319\, y$$

$$T_{TOP} = 27.9 + .319(21.59)$$
$$= \underline{34.8 \ \#/IN}$$

$$T_{NA} = 27.9 \ \#/IN$$

$$T_{BOT} = 27.9 + .319(-71.91)$$
$$= \underline{5.0 \ \#/IN}.$$

$$p'_{NA} = \frac{27.9}{90}$$
$$= \underline{.310 \ PSI}$$

STA 105.

$$M_a = 1003(165.8 - 105) + 802(22.6 - .25) - 23,570 + 25,900 - .25(-571 + 570)$$
$$= 61,000 + 17,900 - 23,570 + 25,900$$
$$= 81,230 \ IN.\ LB.$$

$$P_A = 802 + 12,000(.2) + (25)(6)(2)(72.0) - 571 + 570$$
$$= 802 + 2,400 + 21,600$$
$$= 24,800 \ LB.$$

MOM. PRES.

$$M_p = -(2)(6)(72)(25)(21.75 - 3) + (.20)(12000)(20.59 - .25)$$
$$= -405,000 + 48,800$$
$$= -356,200 \ IN.LB.$$

(REF PP.

AFT BODY: SHELL
MEMBRANE TENSION.

STA 105 (CONT.)

$M = 81,230 - 356,200$
$= -275,000$ IN.LB. (REF PG. 75)

$T = \frac{24800}{858} + \frac{275000}{879,600} y$ (REF PP. 75)
$= 24.8 + .313\, y$.

$T_{TOP} = 24.8 + (.313)(21.75)$ (REF PG. 75)
$= \underline{31.6}$ #/IN

$T_{NA} = \underline{24.8}$ #/IN

$T_{BOT} = 24.8 + (.313)(-74.85)$
$= 24.8 - 23.4$
$= \underline{1.9}$ #/IN

$p'_{NA} = \frac{24.8}{90}$
$= \underline{.276 \text{ psi}}$.

STA 125.4

$M_A = 1003\,(165.8 - 125.4) + 802(226 - 7.05) + 580 + 25,900$
$- 7.05(4 + 570)$
$= 40,500 + 12,500 + 600 + 25,900 - 4,000$
$= \underline{75,500}$ IN. LB.

$P_A = 802 + 11950\,(.2) + (6)(25)(2)(78.6) + 4 + 570$
$= 802 + 2390 + 23,580 + 4 + 570$
$= \underline{27,350}$ #.

MOM. - PRES

$M_p = -(2)(6)(25)(186)(19.75 - 3) + (.2)(11950)\,(27.00 - 7.05)$ (REF. PP.
$= -395,000 + 47,700$
$= \underline{-347,300}$ IN.LB.

$M = -347,300 + 75,500 = \underline{-271,800 \text{ IN.LB}}$

AFT BODY SHELL
MEMBRANE TENSION

STA 125.4 (CONT)

$$T = \frac{27350}{905} + \frac{271800}{814600} y \qquad \text{(REF. PG. 76)}$$

$$= 30.2 + .334y$$

$$T_{TOP} = 30.2 + .334(19.75)$$

$$= \underline{36.8 \ \#/IN}$$

$$T_{NA} = \underline{30.2 \ \#/IN}$$

$$T_{BOT.} = 30.2 + .334(-72.55)$$

$$= \underline{6.0 \ \#/IN}$$

$$P'_{NA} = \frac{30.2}{90}$$

$$= \underline{.335 \ PSI.}$$

STA. 147.0

$$M_2 = 1003(165.8 - 147.0) + 802(22.6 - 18.45) + 3,210 + 25,900$$
$$-18.45(58 + 570)$$

$$= 18,900 + 3,300 + 3,200 + 25,900 - 11,600$$

$$= \underline{39,700} \ IN.LB.$$

$$P_A = 802 + 9820(.2) + (2)(6)(25)(80.6) + 58 + 570$$

$$= 802 + 1964 + 24180 + 58 + 570$$

$$P_A = \underline{27600} \ LB.$$

MOM. - PRES

$$M_P = -(2)(6)(25)(80.6)(16.05 - 3) + (2)(9820)(35.45 - 18.45)$$

$$= -315,500 + 33,400 \qquad \text{(REF. PP. 71 \& 74)}$$

$$= \underline{-282100 \ IN LB}$$

$$M = -282,100 + 39,700$$

$$= \underline{-242,400 \ IN LB.}$$

AFT BODY SHELL

STA 147 (CONT) MEMBRANE TENSION

$$T = \frac{27600}{894} + \frac{242400}{544600} y \qquad \text{(REF PG. 77)}$$
$$= 30.9 + .445 y$$

$$T_{TOP} = 30.9 + .445(\cancel{15.5})$$
$$= \underline{38.0 \ \#/IN}$$

$$\underline{T_{NA} = 30.9 \ \#/IN}$$

$$T_{BOT} = 30.9 + .445(-62.15)$$
$$= \underline{3.2} \ \#/IN$$

$$p_{NA} = \frac{30.9}{90}$$
$$= \underline{.343 \text{ psi}}$$

STA 152.5

$$\left[\frac{168.8 - 152.5}{168.8 - 147.0} = .748\right]$$

$$M_a = 1003(165.8 - 152.5) + 802(22.6 - 22.05) + .748(3210) + 25,900$$
$$- 22.05[.748(58) + 570]$$
$$= 13,300 + 400 + 2,400 + 25,900 - 13,500$$
$$= \underline{28,500 \ \text{IN. LB.}}$$

$$P_A = 802 + .2(8820) + (2)(25)(6)(79.4) + .748(58) + 570$$
$$= 802 + 1764 + 23,820 + 43 + 570$$
$$= \underline{27,000 \ lb.}$$

NOM. PRES.

$$M_p = -(2)(25)(6)(79.4)(14.75 - 3) + (1.2)(8820)(37.70 - 22.05)$$
$$= -279,900 + 28000 \qquad \text{(REF PP. 72 \& 74)}$$
$$= \underline{-251,900 \ \text{IN LB}}$$

$$M_1 = -251,900 + 28,500$$
$$= \underline{-223,400 \ \text{IN LB}}$$

AFT BODY SHELL

MEMBRANE TENSION

STA 152.5 (CONT.)

$$T = \frac{27000}{871} + \frac{223400}{447100}\,y$$
$$= 31.0 + .500\,y.$$

$$T_{TOP} = 31.0 + .500(14.15)$$
$$\underline{= 38.4 \ \#/IN}$$

$$T_{NA} = \underline{31.0 \ \#/IN}$$

$$T_{BOT} = 31.0 + .500(-57.75)$$
$$= \underline{2.1 \ \#/IN}$$

$$p'_{NA} = \frac{31.0}{90}$$
$$\underline{= .344 \ psi}$$

THE NEUTRAL AXIS PRESSURES ARE SUBTRACTED FROM THE AVERAGE PRESSURES AT THE VARIOUS STATIONS AND THE REQUIRED TENSION IN THE TRANSVERSE DIRECTION IS CALCULATED BY
$T_t = (p_{AVG} + .2 - p'_{NA})R$.

STA	$p_{AVG}+.2$	p'_{NA}	$p_{AVG}+.2-p'_{NA}$	R	T_t #/IN
93.9	-.419	-.310	-.109	69.6	7.6
105	-.667	-.276	-.391	75.1	29.4
125.4	-.653	-.335	-.318	79.6	25.3
147.0	-.430	-.343	-.087	80.6	7.0
152.5	-.400*	-.344	-.056	79.8	4.5

EST*

BOTH LONGITUDINAL AND TRANSVERSE TENSIONS ARE LOW COMPARED TO THE 375 #/IN & 335 #/IN WARP AND FILL STRENGTHS OF N313 A405 FABRIC USED IN THE SHELL CONSTRUCTION.

PREPARED	A.P.A.
CHECKED	TLH
DATE	
REV DATE	

GOODYEAR
GOODYEAR AIRCRAFT CORPORATION
AKRON, OHIO

PAGE	B 80
MODEL	M-1L
GER-	11141 APP. B
CODE IDENT	25500

AFT BODY SHELL
MEMBRANE STRESS

THE CRITICAL SHEAR BUCKLING STRESS IS:

$$\tau_{cR} = \sqrt{\sigma_1 \sigma_2}$$

STA	$\sigma_1 = T$	$\sigma_2 = T_t$	$\sigma_1 \sigma_2$	τ_{cR}
93.7	27.9	7.6	212.0	14.6
105	24.8	29.4	729.1	27.0
125.4	30.2	25.3	764.1	27.6
147.0	30.9	7.0	216.3	14.7
152.5	31.0	4.5	139.5	11.8

THE SHEAR STRESS IS:

$$f_s = \frac{VQ}{2I}$$

$$= \frac{802}{2} \frac{Q}{I}$$

$$= 401 \frac{Q}{I}.$$

STA	R	$\bar{y}$	COS α	SIN	α	A	y'	$y'-\bar{y}=y$	$Ay=Q$	I	Q/I	f_s #/IN
93.9	69.6	2.31	-.0332	.9995	1.604	223.5	-43.4	-45.71	-10220	770300	-.0133	-5.33
105	75.1	-.25	.0033	1.0000	1.568	235.5	-47.9	-47.65	-11220	879600	-.0128	-5.13
125.4	79.6	-7.05	.0885	.9961	1.482	236.0	-53.5	-46.45	-10960	814600	-.0135	-5.41
147.0	80.6	-18.45	.2290	.9234	1.340	216.0	-58.5	-40.05	-8650	544600	-.0160	-6.42
152.5	79.8	-22.05	.2765	.9610	1.291	206.0	-59.4	-37.35	-7700	447100	-.0173	-6.94

$$\cos\alpha = -\frac{\bar{y}}{R}$$

$$A = 2\alpha R$$

$$y' = -R \sin\alpha / \alpha.$$

$$Q = A(y' - \bar{y})$$

$$M.S. = \frac{11.8}{6.94} - 1$$

$$= .70$$

JR-218 (7-61)M
REF: ENGRG PROCEDURE S-017

"AIRMAT" FACE STRENGTH

THE DACRON "AIRMAT" HAS 112 - 220 DENIER WARP COUNT, 40 TO 43 - 220 DENIER FILL COUNT, AND A NOMINAL 47.2 DROP THREADS PER SQUARE INCH. TESTS SHOWED THE AVERAGE YARN STRENGTH TO BE 3.26 LB., AND THE AVERAGE LOOP STRENGTH 80% OF THAT OR 2.6 LB. THE LATTER WILL BE CONSERVATIVELY USED FOR THE WOVEN AIRMAT CLOTH. THEN THE ESTIMATED STRENGTHS ARE:

WARP	291	LB/IN.
FILL	104	LB/IN. (BASED ON 40 COUNT.)
DROP	122	LB/IN.²

THE TWO 45° BIAS COVER PLIES HAVE AVERAGE CLOTH STRIP STRENGTHS OF 262 (WARP) x 247 (FILL) OR 250 x 230 (SPEC), GOODYEAR CODE 482). THE STRENGTH OF THE PLIED FABRIC CAN BE ESTIMATED WITH THE HELP OF GER 9145, WHICH GIVES:

$$\sigma_X = T_{W1}\cos^2\alpha_1 + T_{W2}\cos^2\alpha_2 + T_{F1}\sin^2\alpha_1 + T_{F2}\sin^2\alpha_2 .$$

$$\sigma_Y = T_{W1}\sin^2\alpha_1 + T_{W2}\sin^2\alpha_2 + T_{F1}\cos^2\alpha_1 + T_{F2}\cos^2\alpha_2$$

ASSUME:

$$T_{W1} = T_{F1} = 250 + 230 = 480 \text{ LB/IN.}$$

$$T_{W2} = 291 \text{ LB/IN.} \quad T_{F2} = 104 \text{ LB/IN.}$$

THEN:

$$\sigma_X = .5\,T_{W1} + T_{W2} + .5\,T_{F1} + 0$$

$$= T_{W1} + T_{W2} .$$

$$\sigma_Y = .5\,T_{W1} + 0 + .5\,T_{F1} + T_{F2}$$

$$= T_{W1} + T_{F2} .$$

IF STRAIGHT AND BIAS STRAINS AND STIFFNESSES ARE EQUAL AS ASSUMED IN GER 9145 PG. 9, $\sigma_X = 480 + 291 = 771$ LB/IN AND $\sigma_Y = 480 + 104 = 584$ LB/IN. IN GER 9145 THREE DACRON 45° B/S FABRICS HAD EFFICIENCIES (BASED ON SIMILAR THEORETICAL CALCULATIONS) AS LISTED IN THE TABLE AT TOP OF FOLLOWING PAGE.

"AIRMAT" FACE STRENGTH (CONT)

DACRON 45° B/S FABRIC EFFICIENCIES (TWO PLIES)

STRESS RATIO	EFFICIENCY - %
1.03	71
2.0	55, 59, 67, 67, 67
1.35, 1.32, 1.26	69, 64, 50
1.10, 1.08, 1.09, 1.07	56, 59, 68, 72
0.91	68
1.58	65
1.47	68
AVG.	64

HOWEVER, 2-PLY B/S FABRICS USING 482 CLOTH SHOWED AVERAGE CYLINDER BURST STRENGTHS OF 417 X 419 LB/IN. THE THEORETICAL STRENGTH OF THIS FABRIC WOULD HAVE BEEN 247 + 262 = 509 LB/IN. (ARBITRARILY ASSUMING ONE WARP AND ONE FILL (EITHER BIAS OR STRAIGHT EFFECTIVE). EFFICIENCY: $\frac{419}{509}100 = 81\%$. THE SPECIFICATION CYLINDER BURST WAS MUCH LOWER THAN ~~THE~~ AVERAGE (375 X 335). BASED ON THE SPEC. VALUES THE EFFICIENCY IS $\frac{335}{480}100 = 70\%$ APPLYING THE EFFICIENCY DERIVED FROM SPEC. VALUES AS A REASONABLE AVERAGE VALUE, THE STRENGTH OF THE "AIRMAT" SURFACE IS ESTIMATED AS:

$.70(584) = 409$ LB/IN. (FILL)
$.70(771) = 539$ LB/IN. (WARP)

FROM PG 58 THE MAXIMUM MOMENT IS 254 IN LB/IN.

THE MAXIMUM FABRIC TENSION IS

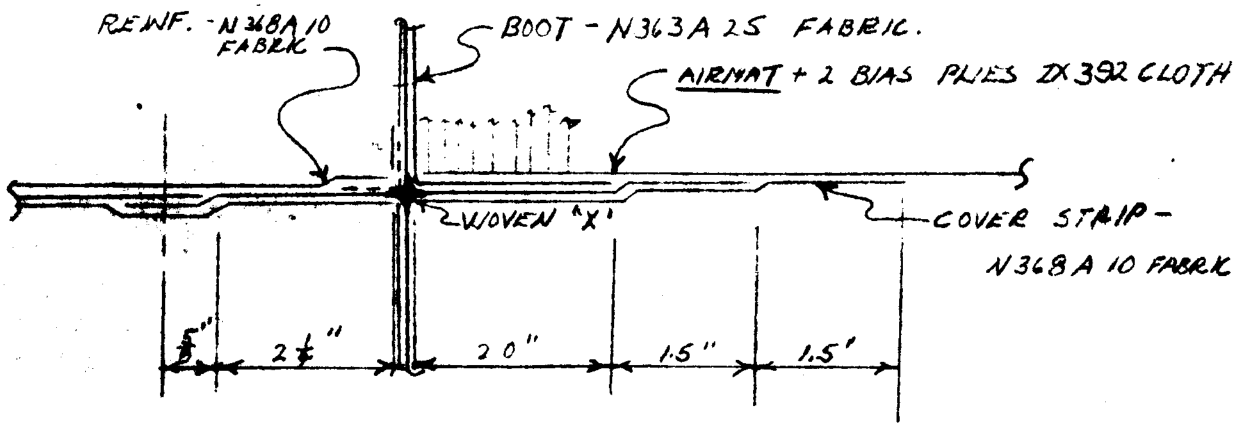
$$\frac{254}{6} + 20\left(\frac{6}{2}\right) = 102 \text{ LB/IN}$$

$$F.S. = \frac{409}{102} = 4.0 \quad \text{(SHORT TIME)}$$

$$F.S = \frac{409}{60} = 6.8 \quad \text{(LONG TIME)}$$

TYPICAL SEAM M-1-L

FULL FABRIC STRENGTH SEAMS ARE USED ONLY AT FIN, FIN SUPPORT-TOP SURFACE INTERSECTION AND THE INTERNAL CURTAIN-TOP SURFACE INTERSECTION. THE OTHER EDGES ARE MADE WITH STAGGARD PLY SPLICES THE TYPICAL SEAM CONSTRUCTION IS SHOWN SCHEMATICALLY BELOW.



TYPICAL M-1L SEAM

REF DWG. 62QS987

THE SHEAR STRENGTH OF A 3.5 IN. SINGLE LAP NEOPRENE CEMENTED JOINT IS 710 LB/IN (RE GER 10346 PG C-5.07).

THE FABRIC STRENGTHS AR

AIRMAT FACE	539/409 (EST.) (REF PG. 82)	
N 368 A10	300 LB/IN (SPEC)	REF DWG 59QS889
N 367 A25	120/100 LB/IN (SPEC)	REF DWG 59QS889
WOVEN "X" LEG	650 LB/IN (TEST)	

INSPECTION OF THE ABOVE NUMBERS INDICATE THE SEAM STRENGTH SHOULD EXCEED THE AIRMAT FACE STRENGTH.